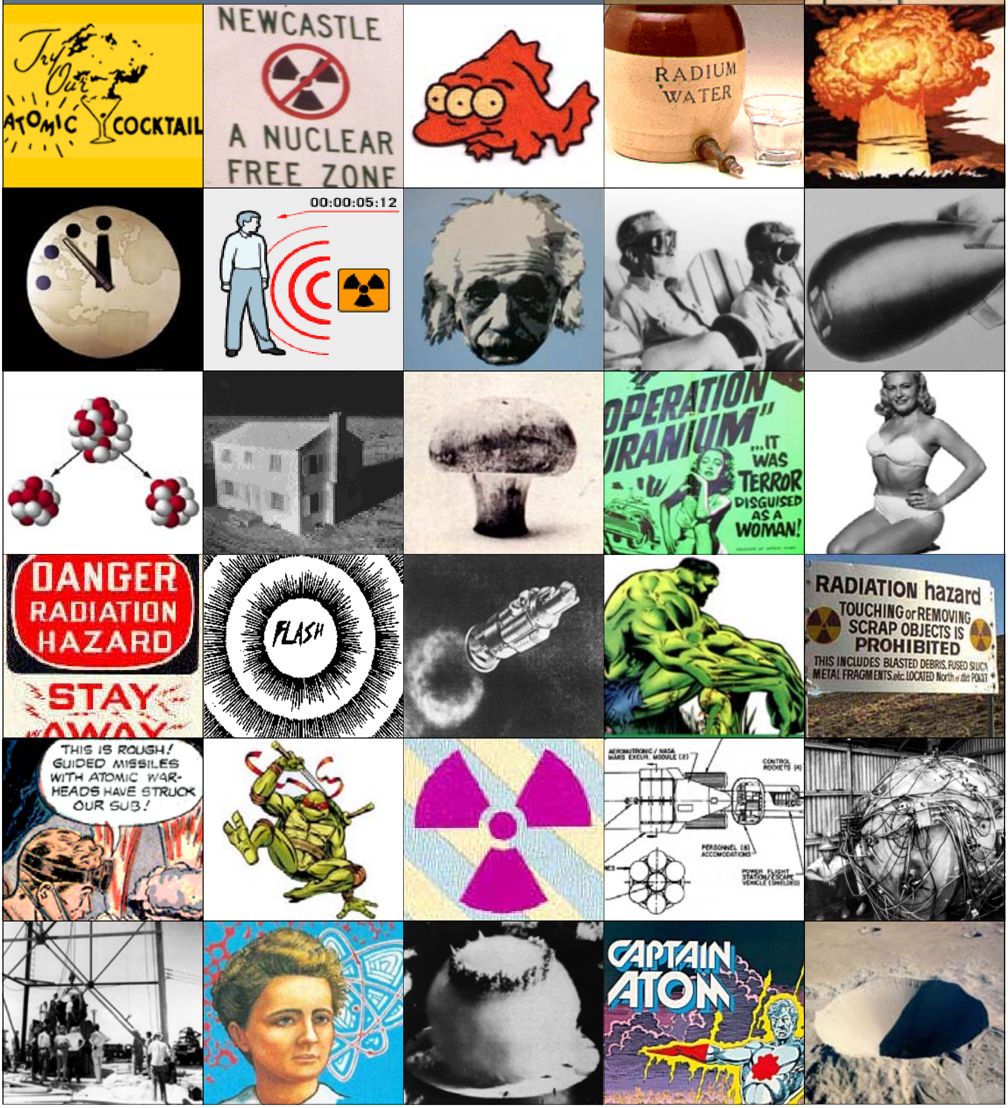
nerdling

special nuclear issue



introduction

At **nerdling** we're not afraid to admit that we're shit-scared of the atomic bomb. We're also pretty bloody terrified of nuclear waste being mishandled. But these are issues of politics and management, not nuclear science.

I had a discussion about Chernobyl with an academic the other day, where he said, to substantiate his point that nuclear power facilities are safe, "The system itself was fully under control. It was only because the operators panicked and overrode several safety systems that there was any sort of problem." Inadvertently he hit the nail on the head: every good engineering course stresses that people are just as much a part of the system as any nut or bolt or control computer. And until crazy well-intentioned people stop overriding safety systems, or crazy people stop making more nuclear bombs, or crazy people stop dumping nuclear waste in places where it shouldn't go, then we'll continue to be scared of these things.

However, once the focus moves away from the crazy people and onto the radiation itself, we're in a totally different situation. This is where science empowers us.

The role of science in nuclear issues is the same as in any issue—it is not to deny us the right to moral standpoints and empathic arguments (despite the impression some deadened scientists may give), but rather to allow us to make those arguments stronger by giving us more information. Becoming a scientist does not mean you cease to be a person, and nor does it mean you immediately start pissing off your friends and family by turning single-mindedly pro-nuclear and insisting that they're all uneducated hippies if they disagree. As physicist Erwin Schrödinger put it, the ultimate purpose of science is the same as the purpose of the arts—that is, to answer the question "And we, who are we anyway?" Science is about finding out more about life and the world around us, in order to understand it better. With more knowledge of a physical system, we need to fear it less.

This is particularly pertinent with respect to nuclear science and radiation—both the ionising radiation dealt with in this zine, and non-ionising radiation such as emitted by mobile phones—which are perhaps the most feared and misunderstood areas of science relevant to our daily lives. Because it's invisible, we have to rely on experts to tell us if it's really there. This has elevated the mobile-phone radiation debate to a level where accusations of conspiracies and cover-ups are being made. The same sort of vague fear exists about computer monitors: people I know use radiation filters over their screens 'just to be sure'. And only a few months ago a boy at a local school was exposed to a caesium radiation source he found on the road, which resulted in him being rushed to hospital for a full check-up and the story making national news as a 'radiation scare'—whereas, in reality, you might be able to find a vase in your grandmother's house that's more radioactive than that caesium source (the glaze on old vases commonly contained uranium due to its pretty honey-brown colour). But this didn't stop the story from being a media sensation.

In almost all cases, fear of radiation has done more damage than the radiation itself. Following Chernobyl, thousands of people in Russia were forcibly and permanently moved off their land due to a fear of contamination—when in many places the radiation levels would, in fact, have dropped to near-background levels in only a few days. The suicides resulting from the trauma of losing all their land and heritage took a greater toll on the population than the ra-

diation would have caused. And when the European public heard about the plume from Chernobyl that was carried over the continent, abortions of foetuses skyrocketed—again, unnecessarily.

Remember, radiation itself is not intrinsically bad. It’s all around us; right now there is radiation from the earth’s crust and from the sun zipping through your body all over the place, not doing you any harm. Your body itself contains Carbon-14 and Potassium-40, which are radioactive particles zapping away at your DNA non-stop—which is why our body has developed mechanisms to deal with most DNA damage from radiation before it goes on to form a cancer. It’s the crazy people that are the problem—but that’s the case with everything. Remember, the fact that a bloody big asteroid could come and wipe most of the life on earth doesn’t mean we have to be afraid of rocks in general. So too with radiation.

This zine does not even try to be a comprehensive guide to radiation. That’s what textbooks are for. We’ve thrown in just enough science to give you a feel for what’s going on, and then it’s up to you to find out more if you’re interested. There are some good references cited along the way for further reading.

Sit back, strap on your weird radiation-proof goggles, and enjoy the zine.

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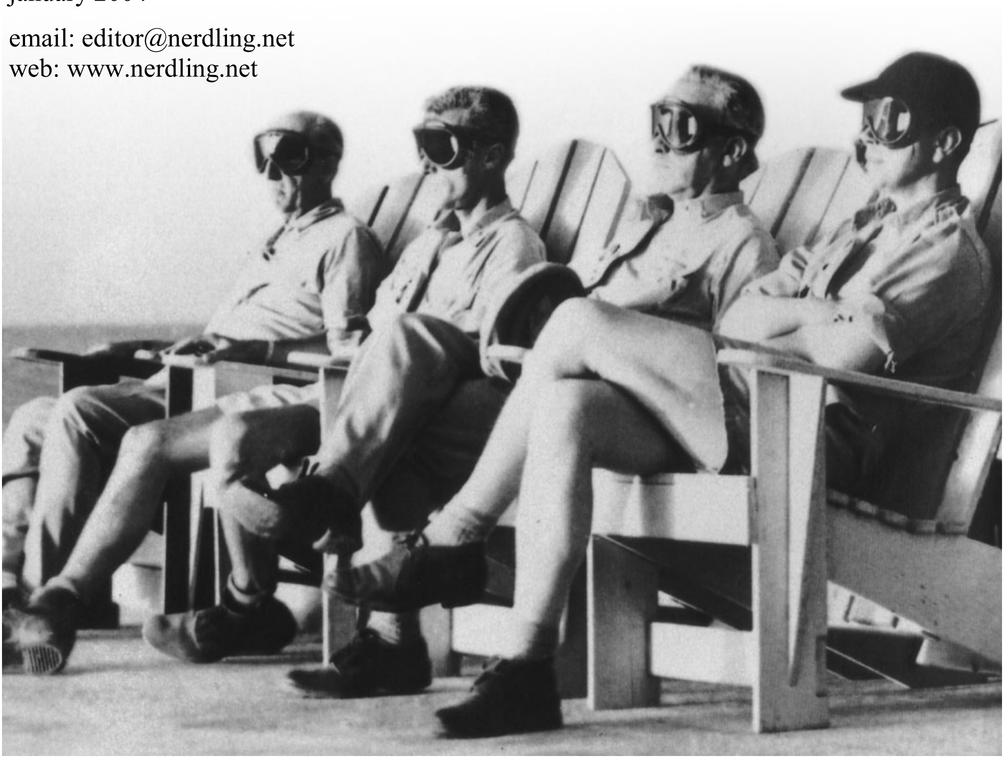
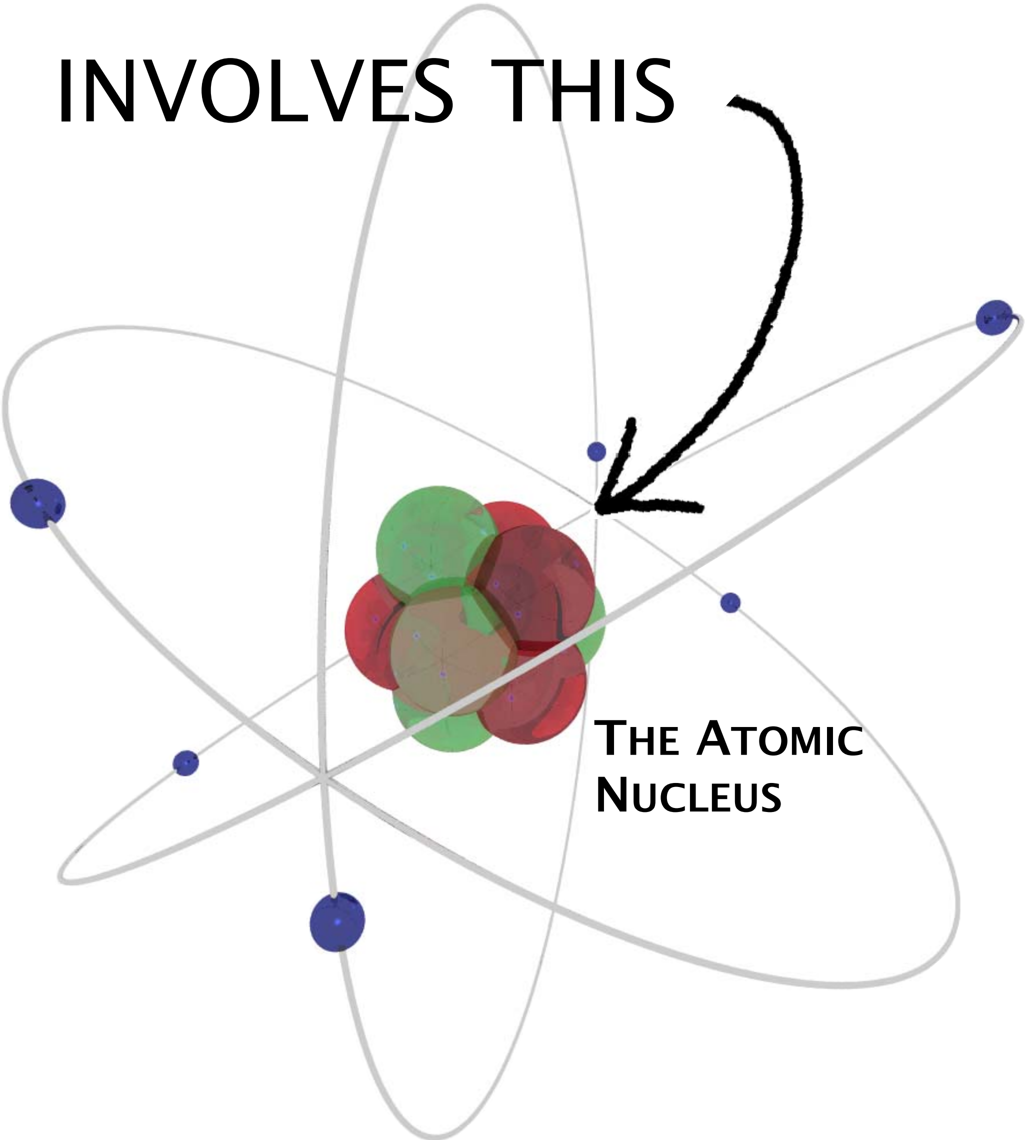


contents

The Reactor

EVERYTHING IN THIS ISSUE INVOLVES THIS



- The atomic nucleus consists of protons and neutrons (called *nucleons*) tightly packed together. Protons have a positive charge while neutrons have no electrical charge. Both weigh about 1.7×10^{-27} kg; in other words it would take about a thousand million million million million of them to make up a gram.

- The number of protons determines which chemical element the atom is. There are usually at least the same number of neutrons present, and sometimes more. Atoms of the same element, but with different numbers of neutrons, are called isotopes (from the Greek *isos* meaning 'same' and *topos* for 'place' - having the same place in the periodic table).

- Protons and neutrons are about 2 femtometers wide (1fm = 10^{-15}m). If you know *A*, the total number of nucleons, you can find the nuclear radius in femtometers by the formula $R=1.2\times A^{1/3}$. Using this, we can find that a carbon nucleus is about 2.7 fm wide. The width of the whole carbon atom, by comparison, is about 30,000 times greater. You can see that the picture to the left is hardly drawn to scale.

- The nucleons are held together by the Strong Nuclear Force. It only acts over very short distances of about 1 fm, but is the strongest force known: between two neighbouring protons, the strong nuclear force is about 100 times greater than the electrostatic force and roughly 10^{34} times stronger than the gravitational force.

- It looks fairly innocent. Don't let this fool you.

the one-page guide to radioactivity

For those of us who aren't exactly Marie Curies, we've condensed most of the boring science in this zine to just one page. If you're interested in an introduction to radiation science and measurement, get stuck into the print below. Otherwise, skip over a few pages to where there's some pretty wacky stuff and a few cartoon characters and big explosions to keep you entertained.

Ionising radiation, the stuff we're concerned with in this zine, is nothing but little particles zapping out at you. Mostly these particles are spat out of heavy elements like uranium, or unstable isotopes like carbon-14, both of which would rather exist as something else.

There are many particles which can be considered 'radiation', but most often we're concerned with alpha particles (pretty large, made of two protons and two neutrons), beta particles (a fancy name for flying electrons), gamma rays (just high-energy light), x-rays (more high-energy light) and neutrons.

Radiation can be dangerous to living organisms because it can knock bits out of important molecules. Contrary to popular belief, our bodies are getting zapped with natural radiation all the time. This radiation can occasionally mess with our DNA, but our body is actually pretty good at repairing this damage on the level of day-to-day exposure.

How to measure radiation? Here's where researching radiation can be like trying to navigate through a quagmire using a map written randomly in seven different languages.

There are seven different units for measuring radiation, summarised in the table below, and converting between them is not as easy as you might think. So why is measuring radiation not as straightforward as measuring length or time? Well, unlike length or time we're not only interested in the physical properties of the radioactive substance, but also its effect on humans. This effect varies with the type of radiation, the exposure amount, and the exposure time.

A Geiger counter can register each time one of these particles passes through a given space. This gives a reading in Bequerels (or Curies). However, this measurement will not only vary with the distance from the source but also the size of the detector. It also gives no information about how damaging the particles are to tissue.

The unit Gray takes the energy of the particles into account, and the Sievert takes the energy *and* the level of tissue damage into account. To calculate the dose in Sieverts, one takes the dose in Grays and multiplies it by a 'quality factor' (QF) corresponding to the particles' ability to damage tissue. This factor is exactly 1 for x-rays, approximately 1 for gamma and beta rays, 2-5 for thermal neutrons, about 10 for fast neutrons and protons, and 10-20 for heavy charged particles such as alphas.

As an example, say I want to compare the radioactivity of a barrel of nuclear waste (15 millirem) to the activity of the uranium dye in an old vase I own, which registers 1500 counts per minute on a Geiger counter. To convert the units from counts per minute to millirem is not as easy as you might think. There are actually at least seven different units commonly used to measure radiation. In this case we'd first have to convert the 15 millirem (old unit, like the mile) to Sieverts (new unit, like the kilometre). Then we'd have to find out exactly what kind of radiation the waste was giving out (less easy than you think) and use this to convert to Grays (radiation energy per kilogram of your body), and then to Bequerels (counts per minute). Then you'd have to analyse the type of radiation given off by my uranium vase to find out the proportion of alpha particles, which aren't going to be picked up by the detector (they can't penetrate the casing) and hence need to be mathematically compensated for. By this time the numbers can be compared, but are probably so full of guestimates that it's hardly meaningful anyway.

If you can read this, you're way too enthusiastic.

Table 1: Units Suck

Name	Standard Unit	Old Unit
Activity of Source	Becquerel (Bq) = 1 disintegration/s	Curie (Ci) = 3.7×10^{10} Bq
Absorbed Dose	Gray (Gy) = 1 J/kg	rad = 10^{-2} Gy Roentgen = 8.7 mGy
Dose Equivalent	Sievert (Sv) =(dose in Gy)×QF	Rem = 10^{-2} Sv

Marie Curie: Radiation Pioneer, Total Babe.

Not only did she win two Nobel prizes for her pioneering work on radioactivity, risk her life to build and bring mobile x-ray units to the front lines of the war, and establish the use of radiation in medicine at the expense of her own life, but she lived modestly and always true to her beliefs. A true modern heroine.

Radioactive Jockstraps, Suppositories and Tablets:
Cure Yourself Through Radiation!

Nowadays most people have an acute fear of radiation. Mention to a friend that bananas have quite a high level of natural radioactive potassium and it's quite possible that they will think twice before having another banana split. So it can be quite astounding to discover that as recently as the 1980s people were using commercially available radioactive products in the belief it would bring good health.

The idea goes back to the ancient notion that certain springs have healing properties. For thousands of years, people have journeyed to places like Bath in England and Badgastein in Austria seeking cures in the waters there.

When it was discovered around 1903 that the water in most of these springs was slightly radioactive (due to the presence of radon gas in the ground through which the water flows), the world leapt to the conclusion that radiation was the magical healing agent in the springs.

The *American Journal of Clinical Medicine* published the statement that "Radioactivity prevents insanity, rouses noble emotions, retards old age, and creates a splendid youthful joyous life." According to Professor Bertram Boltwood of Yale, radiation cures worked by "carrying electrical energy into the depths of the body and there subjecting the juices, protoplasm, and nuclei of the cells to an immediate bombardment by explosions of electrical atoms" which was, amongst other things, "an agent for the destruction of bacteria".

The Revigator (1920): Irradiate Your Water

"Results overcome doubts. ... The millions of tiny rays that are continuously given off by this ore penetrate the water and form this great HEALTH ELEMENT—RADIO-ACTIVITY. All the next day the family is provided with two gallons of real, healthful radioactive water . . . nature's way to health."

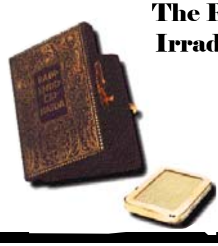
Radon was believed to be the 'life element' of water. Radon was to water what oxygen was to air. Naturally, entrepreneurs took note—radioactivity was going to be big business.

The problem for people seeking radioactive cures was that radon does not stay in water for very long. After a short period, it decays or escapes into the air, meaning it has to be drunk (or bathed in) at the source. An invention in 1912 aimed to overcome this problem and bring the miracle healing properties of radiation to people everywhere. Called the Revigator, it was a "radioactive water crock" made of radium-containing ore which could hold several gallons of water. The instructions on the side read: "Fill jar every night. Drink freely … when thirsty and upon arising and retiring, average six or more glasses daily." The Revigator Company, based in San Francisco, sold several hundred thousand of these products, which they called "a perpetual health spring in the home."

Many copy-cat products quickly followed. The American Medical Association (AMA) was naturally concerned that the public was being fleeced by charlatans. To prevent this they established guidelines (in effect from 1916 to 1929) for a *minimum* radiation level that was acceptable from these devices. If it was putting out *less than* 2 μCi of radon per litre of water in 24 hours, then you were being fleeced! Even the famous Revigator was not radioactive enough to meet these standards. In Australia, too, certain mineral waters were guaranteed by government authorities to be radioactive.

By the 1920s and 30s, it was thought that eating radioactive compounds, or rubbing them directly on to you, could be even more effective than drinking the water. Thus were born radium-containing cosmetics, ear plugs, bath salts, soap, and even suppositories. You could eat a bar of radioactive chocolate, wash it down with a German radioactive beer, and then brush your teeth with radioactive toothpaste. Radium blankets were available to keep you warm at night, and women could wear radium-corsets during the day. Men used radiation treatments to enhance virility, and women used radiation contraceptives in case the mens' treatment unexpectedly worked.

The Radiendocrinator (1930): Irradiate Your Scrotum



"Place Radiendocrinator in the adapter . . . wear like any athletic strap . . . under the scrotum as it should be. Wear at night. Radiate as directed."

The Radiendocrinator (pronounced *Ra*-di-*en*-do-cri-na-tor), for example, consisted of refined radium encased in 14-carat gold and shipped in a velvet-lined leatherette case for \$150—and was designed to be strapped to the scrotum, where it would stimulate the endocrine glands "*which have so masterful a control over life and bodily health*." Also on the market, for only \$1 per box of 42, were Radium tablets designed to be taken with each meal. Then there was the Radium Respirator, which enabled you to breath 'radon-purified' air. To quote the manufacturer: "Radium: scientists found it, governments approved it, physicians recommended it, users endorse it, we guarantee it, SURELY IT'S GOOD!"

Radithor (1928)

"Harmless in every respect."

Radithor was triple-distilled water guaranteed to contain at least 1 microcurie of Radium. Its inventor was William J. Bailey, the same man who brought the world the Radiendocrinator. He proudly used all of his products and claimed to have drunk more radium water than any living man. He died in 1949 of bladder cancer at 64 years of age.

Radithor was advertised as being 'Harmless in every respect." The product slogan proved false in the case of Eben

The Radium Emanation Bath (1925)

Described as being good for nervous disorders, insomnia, general debility, arthritis, and rheumatism. *"Empty contents in a quart of hot water. After a few moments add to regular bath solution. Remain in bath 45 minutes with cover over top of tub. Upon leaving bath relax in bed for one hour."*

Byers, the Pittsburgh industrialist and one-time U.S. amateur golf champion, who, at the recommendation of his doctor, drank three bottles a day of Radithor for two years. Byers stopped consuming Radithor in 1930 when his teeth started falling out and holes appeared in his skull. He died in 1932 at the age of 51.

After Byers' death, the public and the medical profession became more aware of the dangers of radioactive substances, and new laws were put into place banning most of these products. However, this didn't stop their production. Many products were sold throughout the 50s and 60s, continued to flourish in the 80s, and are still being distributed today.

Vita Radium Suppositories (1930)

"Weak Discouraged Men! Now Bubble Over with Joyous Vitality Through the Use of Glands and Radium. Properly functioning glands make themselves known in a quick, brisk step, mental alertness and the ability to live and love in the fullest sense of the word . . . Try them and see what good results you get!"

In the 1960s the Gra-Maze comforter was still being manufactured in Illinois. It was a quilted pad containing uranium ore which could be applied to the body to relieve aches and pains. The company was closed by the government in 1965 following a raid. A similar fate befell the Ionic Research Foundation in Florida, manufacturers of a product to add radon to drinking water.

Another product which continued into the 1960s was the radium-containing Lifestone Cigarette Holder. Inhaling the smoke over the radium was said to diminish nicotine, make the tobacco sweeter and milder, and "protect from lung cancer, promise them beautiful faces, and excellent health."

Degnen's Standard Radioactive Solar Pad (1915-1930)

"Its radioactivity is further increased by exposing the pad to sunlight ... when applied to the body, the pad immediately begins to discharge this energy into the system, sending the lifegiving current through the blood and nervous system."

As recently as 1985 twenty thousand Endless Refrigerator/Freezer Deodorizers were sold in the United States, and are still being sold in Japan today. They consist of a green plastic honeycombed device containing monazite sand, which contains radioactive thorium with a half-life of ten billion years—certainly long enough to justify the 'Endless' name. Users are instructed to hang it in the refrigerator where the emitted radiation is said to purify the air by destroying odours. No details are actually given as to how this is achieved.

Another Japanese product is the NAC Plate, a rectangle about the size of a playing card and coated with

***The* Lifestone Cigarette Holder (1964)**

"Wondrous efficacy of radium emanation protects your health from injurious element in cigarette and makes it sweeter and milder ... [will] protect from lung cancer, promise them beautiful faces, and excellent health."

uranium ore on one side. It is designed to be slipped into a packet of cigarettes where the radiation “denatures and reduces nicotine, tar, and harmful gas” so you can “enjoy … the golden moments of watching smoke rise slowly … with your nerves relieved and refreshed you can get back to work.”

Radiation treatments were still recommended by doctors as recently as the 1980s for the treatment of a number of ailments including, amazingly, acne. Patients exist in our hospitals in Australia today who are receiving treatment for cancers likely sustained as a result of these treatments.

If you still long for the opportunity to expose yourself to the healing powers of radiation, there is a location in the United States where you can go to obtain a radiation cure. The proprietors of the Uranium Health Mines in Montana are proud of their radioactive air, and promote themselves as “The Free Enterprise Radon Health Mine” with “the unmedical approach to arthritis.” Presumably, the wording frees them from the legal constraints of making a medical claim.

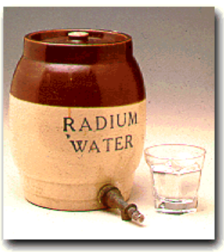
You can get a free ‘radiation treatment’ in the USA just by spending some time in the Rocky Mountain states which, due to their higher altitude and hence lower protection from cosmic rays, have background radiation levels triple that of the Gulf Coast states (and also, surprisingly, has 21 percent less incidence of cancer). Or failing that, you can always go back to basics and take a nice soak in the waters at Bath.

The Nicotine Alkaloid Control (NAC) Plate (1980-present)

"ions emitted from natural ore denature and reduce nicotine, tar, and harmful gas without affecting the original tobacco taste."

Endless Refrigerator/Freezer Deodorisers (1985)

"Natural ion effect destroys odours for years! Outlasts conventional deodorisers. Completely safe."



Product information and pictures obtained from Oak Ridge Associated Universities' **Health Physics Historical Instrumentation Museum Collection** at http://www.orau.org/ptp/museumdirectory.htm

sign of the times

Many towns around the world display signs such as this.

Overlooking the fact that one such sign contains around a million billion billion nuclei, Newcastle is hardly a 'nuclear free' zone.

Even if the average Novocastrian driving up the Pacific Highway heeded the sign to help make the city nuclear free (presumably by dropping off their uranium into a handy roadside collection bin, or cancelling any orders for fission weapons), there remain several problems with the concept...

your city is naturally radioactive

you are not 'nuclear free'

Your own body contains radioactive chemicals including potassium-40, carbon-14 and, yes, traces of uranium. Together they zap your body with about 20,000 particles of radiation every second. We do not die from this because of the efficient systems in our bodies for repairing or terminating damaged DNA strands. If you sleep in the same bed as a spouse or partner you can cop an extra 2 microSieverts per year of radiation exposure, equivalent to living within a few kilometres of a 1000MW nuclear power plant.

the sky is not 'nuclear free'

Cosmic rays from space give us all a dose of radiation equivalent to 6 x-rays per year. If you're living higher than sea level, this amount increases because there is less atmospheric thickness to absorb the rays.

the ground is not 'nuclear free'

Uranium is naturally present in Australian earth and coal at a level of one or two parts per million. Each year in Australia, tens of thousands of tonnes of coal are burnt, releasing hundreds of kilograms of uranium into the environment in the resulting ash and emissions. A 1000MW coal-fired power plant is actually two and a half times more radioactive to its surroundings, than a nuclear plant of the same capacity. Ground rock also contains radium, which decays to radon gas which can cause problems by accumulating in poorly ventilated houses and basements.

your food is not 'nuclear free'

Brazil nuts are naturally quite radioactive, as they are rich in potassium and also tend to take up any radium in the soil. Each nut emits one or two radiation particles every second. Bananas are high in potassium and are likewise quite radioactive. A meat-and-three-veg meal can radiate hundreds of particles per second. Tap water emits about one particle per second per litre. If you think drinking natural mineral water will save you then think again: water from underground springs is likely to be more radioactive due to the presence of radon gas.

continued ➡

your city is necessarily radioactive

hospitals are not 'nuclear free'

Newcastle's John Hunter Hospital, like any other hospital, has a nuclear medicine department. If they handed their radioactive sources in to the Newcastle City Council like the sign asks, many people would die from lack of x-ray imaging, tumour-localising agents, cancer-treating radionuclides and the like.

your house is not 'nuclear free'

It is likely your house contains at least one smoke alarm, which contains the radioactive element americium. Other household items can contain radioactive compounds without being labelled as such, for example some fuel lamps are made brighter by surrounding the flame with a wick coated with radioactive thorium. Many pottery and glass vases from the late 1800s up to around 1950 used uranium as a dye in glazes or glassware. (See page 18.)

industry is not 'nuclear free'

Radioactive iridium-192 and cobalt-60 are used in industry to detect flaws in structures and welds by using an imaging method similar to medical x-rays. Other radioactive sources are used to gauge thicknesses of paper, plastic, and metal. Americium is used in oil exploration. Krypton is used for leak testing of sealed electrical components such as transistors. Even New Zealand, proudly and steadfastly a 'nuclear free' country, has used the beta-radioactive isotope carbon-11 in agricultural studies to learn more about photosynthesis in plants.

conclusion

Newcastle City Council wants you to help make the city nuclear free (unless you are a home owner, doctor, builder, engineer, scientist, or if you eat fruit, nuts or meat, or own old vases, or use coal-generated power.) Anyone else can personally hand their radioactive items to the council chambers, where the Lord Mayor will, we presume, most gratefully receive them.

Compute Your Own Radiation Dose

Source of exposure		Annual Dose in microSieverts
Because you are you		
Internal Potassium-40 in blood and tissue		100
Other internal isotopes (Carbon-14, Polonium, Uranium etc)		250
What you eat		
Natural radioactivity in food and drink		300
Plus contributions of weapons-test fallout worldwide		15
How you sleep		
With spouse, defacto, partner etc **add** from 1 to 3 (depends on how close, and for how long)		_____
How you live		
Medical:	**add** number of chest x-rays times 60	_____
	no. of gastric tract x-rays times 2,000 to 4,000	_____
	number of scans times 1,200 to 24,000	_____
	1,000 for plutonium heart pacemaker	_____
Dental:	**add** number of dental x-rays times 40	_____
TV or VDU viewing: **add** 1.5 times number of hours per day		_____
Regular hot showers using bore water: **add** 700		_____
Jet-setting: **add** 2 per 1000 km travelled		_____
Where you live		
Locality:	Coastal sandstone areas	400
	Granite highlands **add** 300	_____
Building:	Wooden (assuming half time indoors)	500
	If brick or concrete **add** 200	_____
	If poorly ventilated **add** 1,000 or more	_____
Cosmic rays:	At sea-level	260
	For every metre of altitude **add** 0.2	_____
Coal-fired power generation*: World-wide contribution		5
	If living near power station **add** 50	_____
	If living 10 km from station **add** 20	_____
	If living 50 km from station **add** 5	_____
Nuclear power generation*: World-wide contribution		2
	If living near power station **add** 20	_____
	If living 10 km from station **add** 1	_____

(* 1000 megawatt capacity assumed, and spending half time at home)

Total Dose (minimum about 1,800 in Australia): ______

Compare with an Australian average of roughly 2,000 microSieverts.

Editor's Note: the maximum radiation exposure allowed in Australia for the general public is 3000 microSieverts. For radiation workers it is 20,000. The threshold for harm is about 200,000 microSieverts. 1,000,000 microSieverts (1 Sievert) will cause serious sickness, and 5 Sieverts is enough to kill one-half of a population of healthy individuals.

The table above, and much of the information quoted on the previous two pages, were sourced from Nuclear Radiation Exposed *by Colin Keay, The Enlightenment Press, 2001. Copies are available from P.O. Box 166, Waratah, NSW 2298, Australia, or at www.enlightenmentpress.com.*

radiation

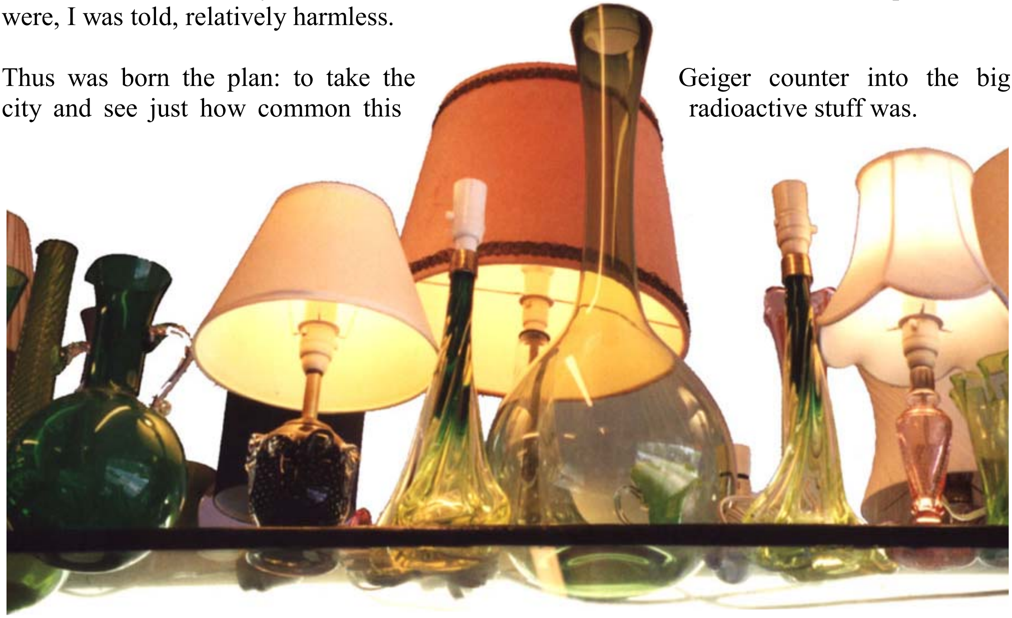
treasure hunt

The plan went like this: borrow a Geiger counter from the physics lab, drive down to Sydney, hit the op- and antique-stores with Katrina, and find a few radioactive objects. Easy.

I already knew that radioactive items are around us more than we think. A few days beforehand, an academic at the university had brought out his clandestine collection of hot objects to show me: a pretty green glass vase, a honey-brown glazed pot, an old plane altimeter, and an unopened packet of kerosene lamp wicks. He'd passed the Geiger counter over them, and the patter of clicks from background radiation went up to a staccato buzz. The needle swung up to a thousand or so counts per minute. For me, who'd only seen it register fifteen counts per minute of backyard cosmic rays, this was pretty cool.

The vases, which looked like any you might find in your grandmother's cabinet, were doped with uranium. It turns out that from around 1880 up to the fifties, it was quite common for uranium to be added to glass to colour it grass-green, or added to pottery lacquers for a tint ranging from orange-brown to green. The plane altimeter clicked because the numbers on the dial had been painted on with glow-in-the-dark radium paint. The kerosene lamp wicks were radioactive because they'd been coated in thorium to make them fire-proof. All were, I was told, relatively harmless.

Thus was born the plan: to take the Geiger counter into the big city and see just how common this radioactive stuff was.



The pair of identical lamp-stands in the foreground, made of uranium-glass, light up even when they're not plugged in.

We started on a corner in Glebe, Katrina and I looking for all purposes like two girls out shopping for pretty things, except that I was packing a Geiger counter and wondering whether I should try to keep it hidden in my bag while taking readings in the shops. I practised a few clandestine sweeps of the sensor wand and decided the secretive thing wasn't going to work. Our best bet was to exude a purposeful confidence and hope people weren't going to freak when we mentioned the r-word.

Measuring the radioactivity of a bronze griffin—500 counts/minute.

We got off to a bad start in the first shop, because almost everything interesting was in locked away in glass cabinets. Just as we were wondering if we would be able to detect anything through the glass, the shopkeeper sauntered over and asked what the gadget was. I explained it was to measure radiation and he got all excited, because it turns out that uranium-glass is quite a collectors' item. He asked if we would mind taking some readings of some things in the shop for him. Not exactly the reaction we'd expected, but hey.

From a shelf of green glass lamp-stands and vases, all of which looked the same colour, he brought down one pair. They were mildly active: 150 counts per minute. Mr Shop Man told us that this pair actually glowed in the dark at night, at which the other two shop keepers looked anxious and moved quietly away to other places in the shop. I measured a few of the other glass objects and found they were all completely silent. Without the detector, the active and non-active items were indistinguishable.

The shop guy seemed to know his stuff about antiques, so when he told us there were no other radioactive things in his shop we believed him—that is, until a quick walk around the shop revealed half-a dozen other radioactive items. A maroon-glazed bronze griffin on the side of a 19th century French porcelain vase shot the needle right up to 500 particles of radiation per minute. An Italian ornamental plant-pot from the same era was coated with a yellow-green glaze that we came to recognise as typically radioactive. The plant looked to be healthy but was not (as yet, anyway) able to talk back to its owners. And then there was a pair of elegant Edwardian vases (same yellow-green colour), an Australian vase from the 1940s (honey brown and green), and an Italian 'jardiniere and stand' (retail value $6750). We pointed them out to the shop owner as we left, just so he knew not to, say, sleep with his head resting near any of them.

continued over —>

Across Glebe and Newtown that afternoon we found so many mildly radioactive items I stopped writing them down. One of the most notable, however, was a radioactive glass lemon squeezer, the type with the pointy island in the middle upon which you impale your half-lemon and twist. Although its activity was very low (only about 100 counts per minute) it poses more of a danger to health than the other objects. This is because uranium glass emits mostly alpha particles, which are large and normally can't penetrate your skin—however, the acid in lemon juice can dissolve some of the uranium out of the glass and into the juice. Once the juice is inside you, the alpha particles can directly damage the cells of your stomach. Even so, the radiation level is so low that the toxicity of the uranium will probably do more harm than the radiation.

The last shop we visited was an unedifying old junk shop on King St, where the guy was just about to close up for the day. We found (and bought, for 18 bucks) a cute sort of honey-brown pot that was registering one and a half thousand counts per minute!

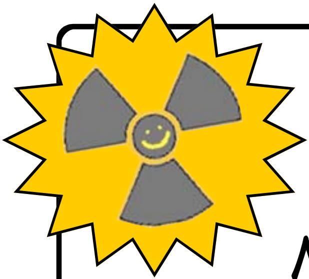
As we walked through the rain to get home, with the pot swinging in a bag near my legs, the question of exactly how dangerous it was became more important. I had to admit that I was operating largely on faith in my uni lecturer, who'd told me they were quite safe. I certainly couldn't say how long you'd have to hold it in your hand to get the equivalent of, say, a medical x-ray.

One thing I did recall, however, was that uranium emitted most of its radiation in the form of alpha particles, which are nice and large and will get blocked by your skin before they can get anywhere nasty. I also knew that alpha particles will get blocked by a piece of paper, so we wrapped the pot in newspaper and took another reading. It was, strangely, exactly the same. Only later did I find out that the Geiger counter can't even register alpha particles anyway, because they can't pass through the detector to register as a click. What the counter was picking up were electrons emitted from thorium, the element to which uranium decays. I started holding the bag away from my body as we walked.

There was, of course, an easy way to work out just how dangerous the vase was—I could have strapped it to my skin for a few weeks and watched to see if there was any damage. This was in fact exactly what Pierre Curie did after the discovery by his wife, Marie, of radium. He simply tied some radium to his forearm and recorded how big the resulting skin lesion became. I decided to take a less direct approach when I got home, and looked up a few comparative values. It turns out that the potassium salts in your body alone give out over four times as much radiation as my vase.

Out of interest, I later took the Geiger counter into the physics labs at uni and stuck it into the box of radiation sources used in experiments. One such source, used in the building industry, made national news earlier in the year when a student at a local high school found it on the road. The reading I got from the box was only slightly higher than the reading from my one vase. It pretty effectively made the point that there is an irrational fear of radiation in our society. When a student and a teacher are rushed to hospital and nuclear experts are called in to deal with a source only about as radioactive as a household vase—of the sort handled by thousands of people each day with no harm—then it would seem there is a need for greater scientific education in this issue.

The moral of the story? Radiation is all around us, often in unexpected places. A little bit of scientific knowledge can go a long way in dispelling fear. And you don't have to be too afraid of the pretty brown or green vases after all.



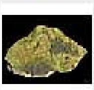
GREAT USES FOR
RADIOACTIVE MATERIALS #1:

MAKE SOME MONEY ON E-BAY

Rocks, Fossils, Minerals

55 items found for **radioactive**

Sort by items: ending first | newly listed | lowest priced | **highest priced**

Picture hide	Item Title	Price	Bids
	Extremely Radioactive Uranium Ore Suite	$32.00	2
	Sizzling Radioactive Torbernite Uranium 65 mR	$31.01	3
	Radioactive Uraninite Crystal...Spain...SHARP	$25.00	-
	RARE & RICH & RADIOACTIVE: Renardite	$25.00	1
	HIGHLY RADIOACTIVE Soddyite...Congo	$25.00	-
	HIGHLY RADIOACTIVE Carnotite...Colorado	$25.00	-
	NICE: Radioactive Marthozite Crystals	$25.00	-
	Highly Radioactive Bayleyite...New Mexico	$25.00	-
	Radioactive Pitchblende w/Asphaltite...Utah	$25.00	-
	Numerous Radioactive Torbernite Crystals	$25.00	-
	Radioactive Uranium ore Collection Atomic	$20.50	3
	CHOICE Radioactive Torbernite Xls...France	$20.00	-
	RARE: Radioactive Kamotoite(Y)	$20.00	-
	Radioactive Uraninite (2)...North Carolina	$20.00	-
	Radioactive Euxenite from Greenland	$20.00	1
	Highly Radioactive Cuprosklodowskite	$20.00	-
	Geiger counter radioactive uranium atomic	$20.00 $35.00	- Buy It Now

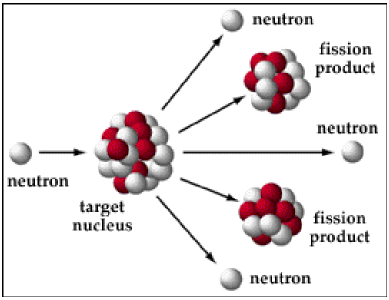
...or spend up and make an investment.
You can get *anything* over the internet, remember.

$E = MC^2$

HERE'S WHERE YOU FINALLY FIND OUT WHAT IT'S USED FOR ▶

HOW THOSE CUTE LITTLE DUDES PACK SO MUCH PUNCH.

NUCLEAR FISSION



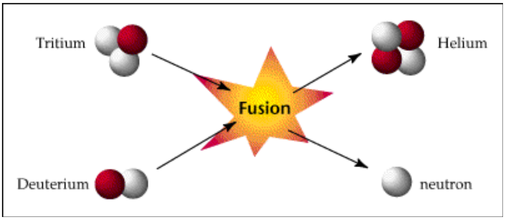
In nuclear fission, a nucleus splits into two smaller 'daughter' nuclei. Several neutrons can also be emitted.

If you could weigh all the products you'd find that they don't weigh as much as the original mass. This 'missing' mass (about 0.1 percent of the original nucleus) has been converted to energy. How much energy? Here's where you use Einstein's famous equation! Multiply the missing mass by the speed of light squared (a huge number). Crank the handle. Out of the formula machine comes the energy produced from splitting that one atom. See, it's not that mysterious.

Fission can occur when the nucleus of a heavy atom captures a neutron, or it can happen spontaneously.

The big deal occurs when there are other heavy nuclei around. The three or so neutrons emitted in the first fission each hit another nucleus. Those three nuclei split and produce three more neutrons each—9 in total. Now nine nuclei are hit and undergo fission, and suddenly we've got 27 neutrons. If unchecked, a massive chain reaction occurs and you've got a nuclear bomb. However, if some neutrons are absorbed before they can cause further atom splitting, the reaction can be stabilised and used in a power plant.

NUCLEAR FUSION



Nuclear energy can also be released by fusion of two light elements. This is the reaction that powers the stars to generate their intense heat and pressure; there, hydrogen atoms are fused to form helium. In a hydrogen bomb, deuterium and tritium (two isotopes of hydrogen) are fused to form a nucleus of helium and a neutron. Like the fission reaction described above, the mass of the products is less than the reactants. This 'missing mass' has been converted to energy according to Einstein's equation.

Why does the mass decrease for both *combining* small nuclei (as in fusion) and for *splitting* a large nucleus (as in fission)? The answer is that the most stable state is a size in between, namely at iron. If the nuclear reaction produces an element closer in size to iron, the reaction will produce energy.

Because the reaction products are non-radioactive and the fuel is plentiful and cheap, fusion is an enticing source of clean energy. However, scientists have not yet been able to design a reactor to contain the temperatures involved, which are greater than 10 million degrees.

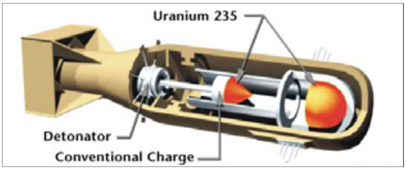
Atomic weapons and fusion energy are discussed more later on in the zine.

KNOW YOUR NUCLEAR WEAPONS. IMPRESS YOUR FRIENDS.

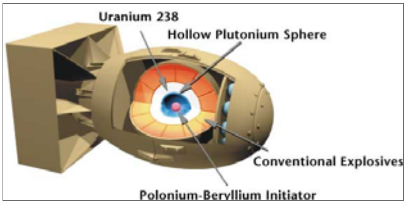
THE ATOMIC BOMB

The atomic bomb involves the **fission** of uranium or plutonium. There are two main types: the gun-type and the implosion-type bomb.

The bomb dropped on Hiroshima, ’Little Boy’, was a gun-type bomb. It fired one mass of uranium-235 at another, thus creating a ‘supercritical’ mass—i.e. one large enough to support a chain reaction. The technical challenge in creating the bomb lay in combining the two masses quickly enough: they had to combine within a microsecond.



The bomb dropped on Nagasaki, ‘Fat Man’, was an implosion-type bomb. It uses both uranium-235 and plutonium-239. Conventional explosives are used to compress the plutonium sphere onto a uranium core much more quickly than the gun-type bomb. The material compresses to a density sufficient to make it go critical and produce a nuclear explosion.



THE HYDROGEN BOMB

The hydrogen bomb is a two-stage affair, using an initial **fission** reaction to ignite a secondary (and more powerful) **fusion** reaction. The uranium fission reaction releases gamma rays and neutrons, which react with lithium deuteride to produce tritium and helium. The tritium and the deuterium (which are both isotopes of Hydrogen) then undergo fusion and release a large amount of energy.

$$\mathrm{Li}^{6}_{3} + \mathrm{n} \rightarrow \mathrm{He}^{4}_{2} + \mathrm{H}^{3}_{1}$$

This is also known as a ‘thermonuclear’ explosion.

THE NEUTRON BOMB

The neutron bomb is a small hydrogen bomb. It differs in the way it will kill you: by the neutron radiation it emits, rather than the blast and heat effects.

This means that a neutron bomb will kill the people right under and around it, but won’t expose people further away to massive doses of radiation. It will also leave most houses and buildings standing. NATO loves this bomb as they believe it will allow them to use nuclear weapons in highly populated areas without necessarily killing hundreds of thousands of people. Wow, that sounds really friendly.

Great Uses for Old Nuclear Weapons #2:

Fight Hurricanes

It seems reasonable to Bob Williams, a retiree from Ohio: if a nuclear bomb can blow apart huge buildings, then why can't it destroy a hurricane? "I am not being whimsical. I'd really like to know," he says.

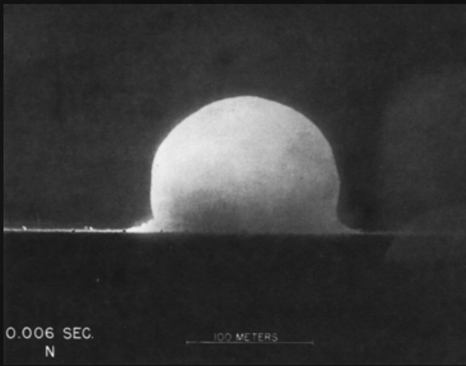
Hurricanes cause about $5 billion dollars of damage per year in the United States. This has led to many people contacting the government's National Oceanic and Atmospheric Administration offering suggestions on how to stop them.

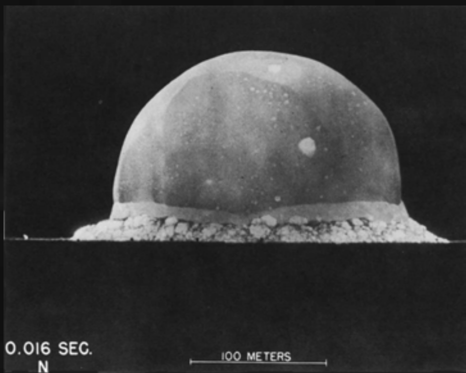
The most common advice: "Nuke 'em." That's followed by the recommendation of conventional explosives. Other techniques actually investigated by the NOAA include artificial rain pattern disruption by cloud-seeding, soaking up the storm with thousands of tonnes of 'Dyn-O-Mat' absorbent flakes, and pumping cold water from the depths of the Atlantic to cool the Gulf Stream by several degrees. This latest method would supposedly stop the air currents that cause tornadoes, although there's a chance it could also change the planet's climate and kill off the marine ecosystem. "I would hate to draft the environmental impact statement for that," says Hugh Willoughby, the former director of hurricane research for the NOAA.

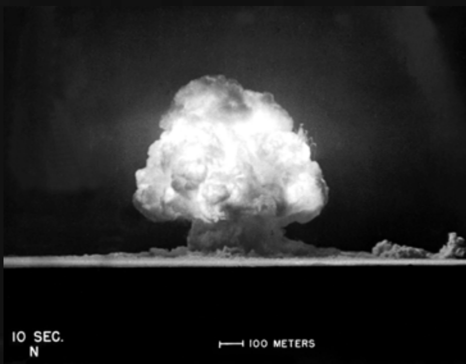
So could nuking a hurricane stop it? It probably wouldn't even make a dint. However, there is the chance that the explosion could fill it with more hot air and make it even bigger. The hurricane would mutate into a radioactive super-hurricane in the manner of the Teenage Mutant Ninja Turtles. It would then drive all over the countryside dropping nuclear fallout in its path.

The Trinity Test

The First Nuclear Explosion
Alamogordo, New Mexico
5:29:45 a.m., 16th July 1945







"In some sort of crude sense which no vulgarity, no humour, no overstatement can quite extinguish, the physicists have known sin; and this is a knowledge which they cannot lose."

"I am become Death, the destroyer of Worlds."

—Dr. J. Robert Oppenheimer, Director of Los Alamos

"Now we are all sons-of-bitches."

—Dr. Kenneth Bainbridge, Director of Trinity Test

Quotes like the ones at top led to Oppenheimer being accused of being a communist during the 'witch-hunts' of 1953. Despite the accusations being widely regarded as baseless, his security clearance was taken away, ending his influence on nuclear policy.

"I was a bit annoyed with Fermi the evening before, when he suddenly offered to take wagers from his fellow scientists on whether or not the bomb would ignite the atmosphere, and if so, whether it would merely destroy New Mexico or destroy the world."

—Lt. General Leslie Groves, Director, Manhattan Project.

(In actual fact, Oppenheimer and Bethe had calculated the chance of atmospheric ignition in 1943. It turned out to be one in $1x10^{20}$.)

Picture above: On 14 July 1945, the bomb was placed on the detonation tower. Lacking confidence in the hoist system, the workers stacked mattresses under the bomb as it was being raised.

The Nevada Nuclear Testing Site
book your holiday now!

In 1950, a 900 square kilometre area in southern Nevada was designated by the United States Government as a nuclear testing area. Six weeks later, testing began. **One of the first detonations shattered windows in Las Vegas, 105 kilometres away.**

A few months later, the Las Vegas Chamber of Commerce was promoting the blasts as a tourist event. They provided maps and calendars to tourists detailing the best location and time for viewing a blast.

The Nevada Test Site was expanded in the 1950s and 60s and now encompasses three and a half thousand square kilometres—bigger than some other states in the USA. Between 1950 and 1963, 126 nuclear bombs were detonated above ground. **928 tests in total have been carried out at the site.**

No large nuclear tests have been carried out since 1992, although low yield nuclear test devices are still detonated below ground. The site is also used for large conventional explosive testing, and as a radioactive waste storage area.

Tourists can still visit the Nevada Test Site. Tours are run once a month and depart from a U.S. Department of Energy building at 2621 Losee Road, North Las Vegas. The DoE advises tourists to bring their own packed lunch, that cameras and binoculars are prohibited, and that "pregnant women are discouraged from participating in Test Site tours because of the long bus ride and uneven terrain." Areas included in the tour have radiation levels almost as low as normal background levels, but tour guide Merl Schwartzwalter assures visitors with a smile **that if they pick up any radioactive dust "it could be wiped off with a piece of paper."**

Electrified Fence Enclosure at Frenchman Lake, Nevada Test Site

Positioned at different distances from Ground Zero, enclosures like this one contained animals during a variety of nuclear tests.

On 24th April 1957, a high-explosive detonation conducted at the Nevada Test Site released plutonium for a field study of contamination. Dogs were placed within the test zone at 4, 5, 16, 32, 64, 128 and 161 days after detonation.

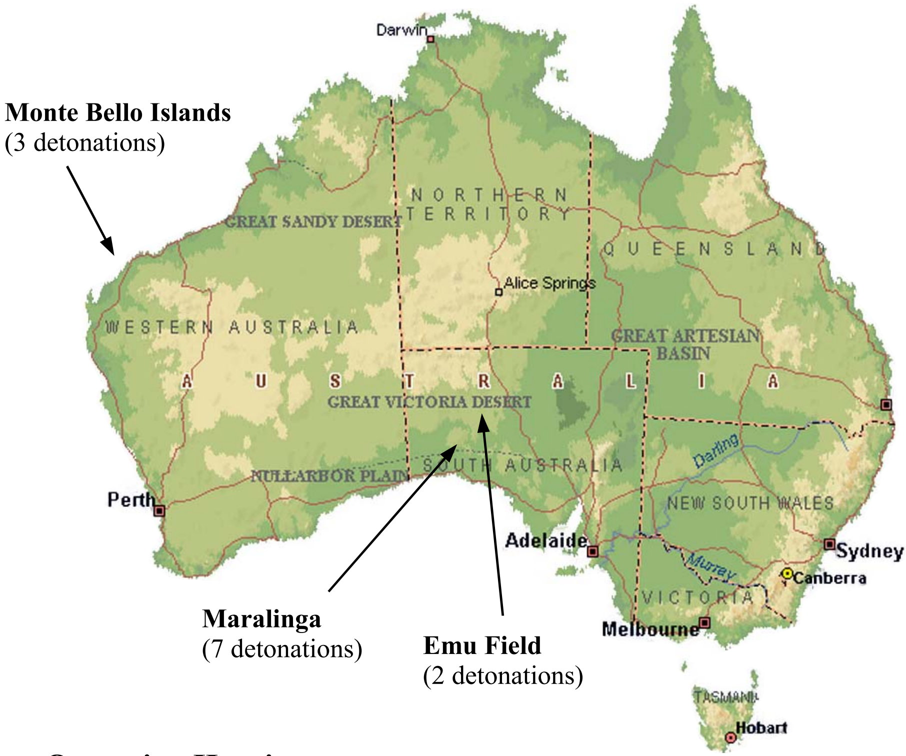
In another test, to determine the effect of nuclear explosions on fabrics, 111 white Chester pigs had special tailored uniforms, with zippers, seams, and drawstrings drawn to match the specifications of standard government-issue field jackets. The pigs were positioned at regular intervals from ground zero, and the effects of the blast were studied and recorded with recommendations for fabric improvement. Seventy-two pigs died immediately, but the U.S. Army gained what it considered important information about the thermal qualities of its uniforms.

Several tests involved rabbits, which were strapped down facing the detonation site in order to measure the blast's effect on the eyes. The rabbits were awakened just before detonation by applying an electric shock to their noses, ensuring their eyes were open when the bomb exploded.

Photograph by Peter Goin: *Nuclear Landscapes*

Nuclear Testing in Australia

12 nuclear bombs have been exploded in Australia. All were above-ground tests carried out by Great Britain between 1952 and 1957. Further small-scale tests were continued until 1963.



Operation Hurricane
(Monte Bello Island)
03 Oct 1952 (25kT)

Operation Totem
(Emu Field)
'T1': 14 Oct 1953 (9.1kT)
'T2': 26 Oct 1953 (9.1kT)

Operation Mosaic
(Monte Bello Island)
'G1': 16 May 1956 (13.5kT)
'G2': 19 June 1956 (56.0kT)

Operation Buffalo (Maralinga)
'one tree': 27 Sept 1956 (12.9kT)
'marcoo': 04 Oct 1956 (1.4kT)
'kite': 11 Oct 1956 (2.9kT)
'breakaway': 22 Oct 1956 (10.8kT)

Antler (Maralinga)
'tadie': 14 Sept 1957 (0.93kT)
'biak': 25 Sept 1957 (5.67kT)
'taranaki': 09 Oct 1957 (26.6kT)

In September 1950, Britain approached Australian Prime Minister Menzies to ask for a favour. They wanted to use Australia to explode some nuclear weapons. Unfortunately, they told us, the technology was a secret, and they couldn't tell us exactly what effects it would have. Australia would just have to trust them that it would be totally harmless and safe.

Menzies said yes, on the spot, without consulting the Australian people, scientific advisors, or even his own government. Members of his cabinet were only informed once preparations of the testing sites were well underway.

From 1952 to 1957, twelve above-ground nuclear bombs were exploded on the Australian mainland, several of them larger than the Hiroshima bomb (≈15kT). Nine of these were on land inhabited by nomadic aboriginal tribes. The Native Patrol Officer was given the impossible task of locating and warning the Aborigines, who were scattered over more than 100,000 square kilometres.

A 1985 Australian Royal Commission investigation into the nuclear tests found that "There was virtually complete government control of the Australian media reporting of the Hurricane test and the lead-up to it, thus ensuring that the Australian news media reported only what the UK Government wished. […] This was to be a recurrent theme throughout the entire weapons testing program."

Bad safety practice, accidents, and following cover-ups were to be the rule rather than the exception. The 1985 report lists "departures, some serious and some minor, from compliance with the prescribed radiation protection policy and standards during the test program." This included getting pilots to fly planes into radioactive clouds to take samples, and sending divers into contaminated water, in neither case with proper safety equipment or decontamination procedures.

At least eight of the 12 explosions were carried out in bad weather conditions, despite previous calculations showing this would lead to unsafe fallout over populated regions.

- The Monte Bello Islands were an unacceptable location for testing because of the strong winds blowing on-shore, which resulted in radioactive fallout over the mainland after each test. After the third test on the island, fallout over Port Hedland exceeded the maximum acceptable level for civilians as used today. This was omitted from reports presented to the government at the time.
- The Totem 1 tests at Emu Field threw a radioactive 'black cloud' over the aboriginal villages of Wallatinna and Welbourn Hill downwind from the test site. Various illnesses ensued and one boy went blind. Contamination had been underestimated by a factor of 3.
- All four Buffalo tests were fired in bad weather conditions, which contaminated Maralinga Village and areas beyond Coober Pedy. Only a lucky wind change at the last minute saved Adelaide from fallout.
- No 'acceptable' levels of radioactive contamination were set by the government for the final three Antler tests, but the Radiation Advisory Committee approved contamination doses twice as strong as usual. Nonetheless, levels from the third test exceeded even these levels.

In 1997 Britain made assurances to the European Court of Human Rights that there was no intention to expose any servicemen or civilians to radiation during the tests. However, in 2001 it was revealed that this was not the case. During the Buffalo trials, twenty four Australian servicemen were deliberately given excessive doses of radiation. They were ordered to run, walk and crawl over Ground Zero hours after detonation. According to the British defense ministry spokesperson, "These were not nuclear tests as such, these were radiation tests on clothing. We were not testing people, we were testing the clothing. People have never been used as guinea pigs." It is also alleged that two groups of seriously mentally and physically handicapped people had been taken to a test area shortly before one of the nuclear tests, and were never seen again.

Many smaller, unofficial explosions were carried out at the test sites. They were designed to investigate the performance of various components of a nuclear device, and mostly involved radioactive materials in conjunction with conventional high explosives.

The first series, known as *Kittens,* was conducted at Emu in 1953 without formal Australian Government approval and without advice being provided to the Australian Government by either Australian or UK scientists. Subsequent series were known as *Rats, Tims* and *Vixen*. The explosions (ironically labelled 'safety experiments') scattered at least 24 kilograms of radioactive cobalt and plutonium pellets across the landscape. British scientists did not inform Australians of the existence of these pellets, and many personnel were exposed to dangerous radiation as a result.

In a half-hearted and unsuccessful attempt at a 'clean-up' after the tests, the British ploughed the testing areas, effectively distributing the radioactive minerals deeper into the ground and making the subsequent Australian clean-up attempt far more difficult and expensive.

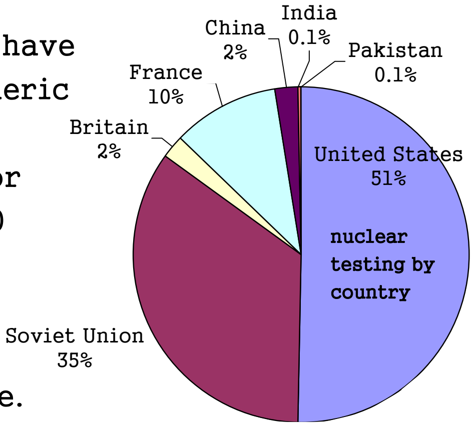
The Australian project to clean up the Emu and Maralinga test sites once and for all started in 1994, with the final report published earlier this year. In the executive summary to this report it is written that "None of the contamination of concern arose from the so-called major trials—the testing of nuclear weapons by evoking a nuclear detonation. Without the minor trials at Maralinga, the rehabilitation program would have been short and simple." The program was completed within budget and on schedule, despite being frequently hampered by grossly incorrect UK records which failed to record the locations of radioactive waste, among other details.

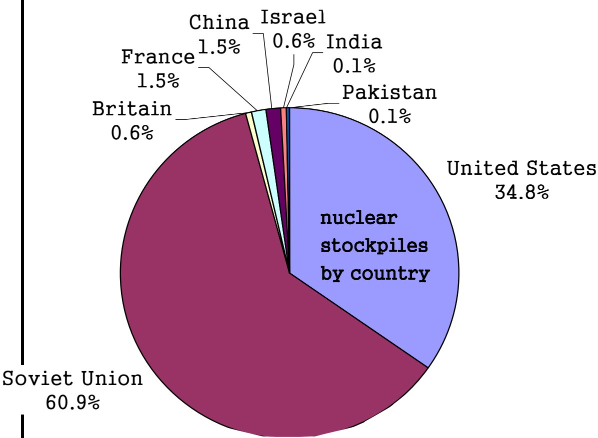
A$104 million was the cost estimated by the Australian Government in 1994 for the clean-up. Despite the 1985 Royal Commission report recommending the UK bear the costs, an agreement between the countries saw the UK pay A$45 million as a final settlement. No money was given by the UK to the aboriginal communities or Australian servicemen as compensation.

Following rehabilitation, the Monte Bello Islands are now part of a Western Australian national marine park.

fun nuclear facts

As of 1998, 2050 nuclear tests have been carried out (528 atmospheric tests and 1522 underground). Fallout from tests has been, or will be, responsible for 17,000 deaths in the U.S. alone. 1.2 million civilians in Russia have weakened immune systems as a result of tests there.





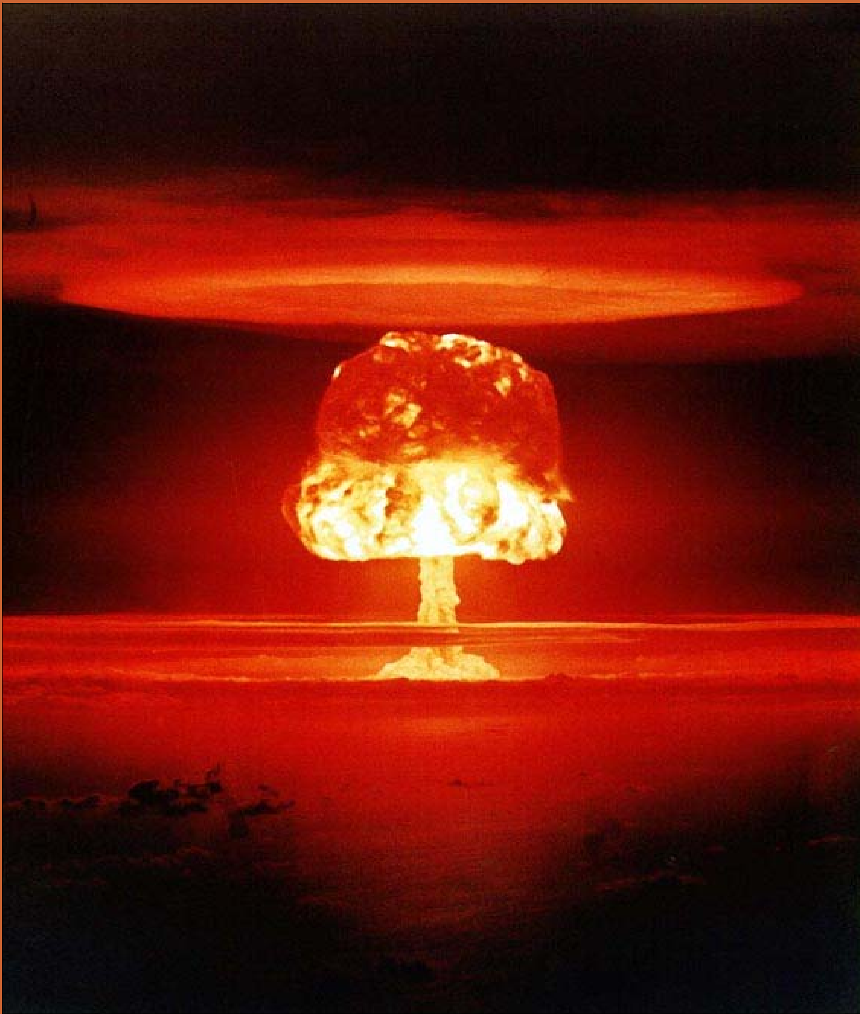
As at February this year, there were approximately 30,000 intact nuclear warheads throughout the world. 17,500 of these are considered operational.

$3.5 trillion: Amount the United States spent between 1940 and 1995 to prepare to fight a nuclear war.

$27 billion: Amount the United States spends annually to prepare to fight a nuclear war.

sources:

- National Geographic, 'Weapons of Mass Destruction', Nov 2002
- Centre for Defense Information, Washington DC
- Oklahoma Geologial Survey Observatory Catalog Of Nuclear Explosions: a list of all known nuclear explosions worldwide, up to July 14, 1998. Available at http://www.batguano.com/nuclear/nuccatalog.html.
- Federation of American Scientists



Science and Nuclear Weapons:

Contrasting Accounts of Nuclear Explosions

"To every man is given the key to the gates of heaven; the same key opens the gates of hell." - Buddhist proverb

The Trinity Test
An account of the first nuclear bomb test by Richard Feynman, physicist

After we'd made the calculations, the next thing that happened, of course, was the test. I went straight out to the site and we waited there, twenty miles away. Time comes, and this *tremendous* flash out there is so bright that I duck, and I see this purple splotch on the floor of the truck. I said, "That's not it. That's an after-image." So I look back up, and I see this white light changing into yellow and then into orange. Clouds form and disappear again—from the compression and expansion of the shock wave.

Finally, after about a minute and a half, there's suddenly a tremendous noise—BANG, and then a rumble, like thunder—and that's what convinced me. Nobody had said a word during this whole thing. We were all just watching quietly. But this sound released everybody—released me particularly because the solidity of the sound at that distance meant that it had really worked.

The man standing next to me said, "What's that?"

I said, "That was the Bomb."

After the thing went off, there was tremendous excitement at Los Alamos. Everybody had parties, we all ran around. I sat on the end of a jeep and beat drums and so on. But one man, I remember, Bob Wilson, was just sitting there moping.

I said, "What are you moping about?"

He said, "It's a terrible thing that we made."

I said, "But you started it. You got us into it."

You see, what happened to me—what happened to the rest of us—is we *started* for a good reason, then you're working very hard to accomplish something and it's a pleasure, it's excitement. And you stop thinking, you know, you just *stop*. Bob Wilson was the only one who was still thinking about it, at that moment.

—Extracted and abridged from "Surely You're Joking, Mr Feynman!", Richard P. Feynman, 1992, Vintage, p135-6

The Hiroshima Bomb
An account of the first nuclear attack by Michihiko Hachiya, physician and director of Hiroshima Communications Hospital.

Dr. Tabuchi, and old friend from Ushita, came in. His face and hands had been burned though not badly, and after an exchange of greetings, I asked if he knew what had happened.

"I was in the backyard pruning some trees when it exploded," he answered. "The first thing I knew, there was a blinding white flash of light, and a wave of intense heat struck my cheek. This was odd, I thought, when in the next instant there was a tremendous blast.

"The force of it knocked me clean over," he continued, "but fortunately, it didn't hurt me; and my wife wasn't hurt either. But you should have seen my house! It didn't topple over, it just inclined. I have never seen such a mess."

"Don't go," I said. "Please tell us more of what occurred yesterday."

"It was a horrible sight," said Dr. Tabuchi. "Hundreds of injured people who were trying to escape to the hills passed our house. The sight of them was almost unbearable. Their faces and hands were burnt and swollen; and great sheets of skin had peeled away from their tissues to hang down like rags on a scarecrow. They moved like a line of ants. All through the night, they went past our house, but this morning they had stopped. I found them lying on both sides of the road so thick that it was impossible to pass without stepping on them."

I lay with my eyes shut while Dr. Tabuchi was talking, picturing in my mind the horror he was describing. I neither saw nor heard Mr. Katsutani when he came in. It was not until I heard someone sobbing that my attention was attracted, and I recognized my old friend. "I walked along the railway tracks to get here [he said], but even they were littered with electric wires and broken railway cars, and the dead and wounded lay everywhere. When I reached the bridge, I saw a dreadful thing. It was

unbelievable. There was a man, stone dead, sitting on his bicycle as it leaned against the bridge railing. It is hard to believe that such a thing could happen!"

He repeated himself two or three times as if to convince himself that what he said was true and then continued: "It seems that most of the dead people were either on the bridge or beneath it. You could tell that many had gone down to the river to get a drink of water and had died where they lay. I saw a few live people still in the water, knocking against the dead as they floated down the river. There must have been hundreds and thousands who fled to the river to escape the fire and then drowned.

"The sight of the soldiers, though, was more dreadful than the dead people floating down the river. I came on to I don't know how many, burned from the hips up; and where the skin had peeled, their flesh was wet and mushy. They must have been wearing their military caps because the black hair on top of their heads was not burned. It made them look like they were wearing black lacquer bowls.

"And they had no faces! Their eyes, noses and mouths had been burned away, and it looked like their ears had melted off. It was hard to tell front from back. One soldier, whose features had been destroyed and was left with his white teeth sticking out, asked me for some water, but I didn't have any. I clasped my hands and prayed for him. He didn't say anything more. His plea for water must have been his last words."

—Extracted and abridged from "Hiroshima Diary",
Michihiko Hachiya, 1955, Gollancz, p26-28

"I also had, as many did, a sense of jubilation at the scientific achievement of splitting the atom […]. The full horror of the bomb did not hit me until the following summer […]. Up to this point, chemistry and physics had been for me a source of pure delight and wonder, and I was insufficiently conscious, perhaps, of their negative powers. The atomic bombs shook me, as they did everybody. Atomic or nuclear physics, one felt, could never again move with the same innocence and lightheartedness as it had in the days of Rutherford and the Curies."

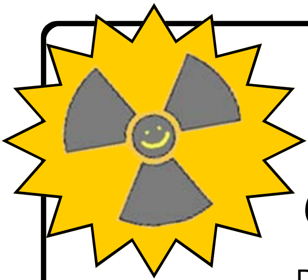
Oliver Sacks, "Uncle Tungsten",

i

“The target was there, pretty as a picture. I made the run, let the bomb go— that was my greatest thrill!”

Nagasaki, August 1945

— Capt. Kermit K. Beahan, bombardier on the B-29 plane *Bock’s Car* which dropped an atomic bomb on the city of Nagasaki on 9 August 1945. The bomb made a crater one mile in diameter and killed 74000 people in the next five months. Beahan spent the night partying, as it was his 27th birthday.



Great uses for nuclear weapons #3 :

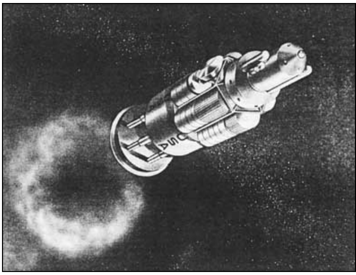
Go to Mars

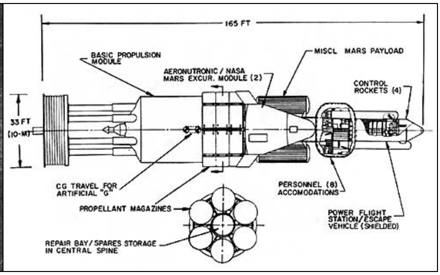
During the space race of the fifties and sixties, the United States government hit on the great idea of using nuclear explosions to blast a spacecraft off the Earth and away to the Final Frontier. They liked the idea so much they gave it a budget and a name: Project Orion.

Project Orion was a spacecraft which would carry several hundred nuclear weapons as fuel. These bombs would be ejected out the back of the craft and detonated at a ‘safe distance’ of about 50 metres. The resulting blast wave would hit a specially designed disc at the back of the ship which would reflect the energy and allow the ship to ‘ride the wave’.

Some of the problems that needed to be overcome in the design included radiation shielding for the astronauts, and shock absorption between the energy reflecting plate and the rest of the ship. This was so that the initial jolt would not shake the craft to pieces and the astronauts would not get cancer.

Considering that about fifty detonations would be required just to get the craft out of the atmosphere, the public seemed justified in being a little concerned about nuclear fallout. Public pressure, together with the Partial Test Ban Treaty of 1963 which prohibited explosions in space, resulted in the project’s cancellation.





Atomic Era

On August 6, 1945 an atomic bomb called 'Little Boy' was dropped on the Japanese city of Hiroshima. At 11:03 a.m., an Associated Press bulletin informed the American public of the event. It only took a few hours before the word 'atomic' had become the hot new way to flog consumer goods.

Before the trading day had closed, the bar at the Washington Press Club was offering a gin and Pernod concoction dubbed the "Atomic Cocktail". The week had not passed before Los Angeles establishments were promoting "Atom Bomb Dancers". A New York jewellery company was selling "atomic inspired pin and earring sets" that were "as daring to wear as it was to drop the first atom bomb." And within months, KIX Cereal was advertising its Atomic 'Bomb' Ring which it was offering to kids for 15 cents and a cereal box top. ("Squint into secret lens and Zowie!… See *real* atoms split to smithereens inside ring.") 750,000 orders were placed. Even the Boy Scouts of America jumped on the bandwagon with an Atomic Energy merit badge.

In the next few years, whole columns of the Los Angeles and New York Yellow Pages filled with 'Atomic' businesses such as the Atomic Hotel, Atomic Food Products, Atomic Sportswear, Atom Cleaners, and even the Atomic Undergarment Co. The Las Vegas Chamber of Commerce saw great promotional and tourist potential in the nearby Nevada Testing Site, and offered tours to watch nuclear explosions. They also instituted the 'Miss Atomic Blast Contest', where the winner wore a coronation bikini with an 88-

Pop Culture


NEW MEXICO ATOMIC JEWELRY is worn by Lovely Pat Burrage of Fort Worth, Tex., who will reign at the "Night in Paradise" at the United Seamen's Service club in New York October. She is shown holding the palladium jewelry inset with atomsite, the substance formed on the ground at the scene of the first atomic bomb test, in New Mexico.

Albuquerque New Mexico Journal September 1945

carat diamond in the bikini top and a smaller diamond in the bikini bottom.

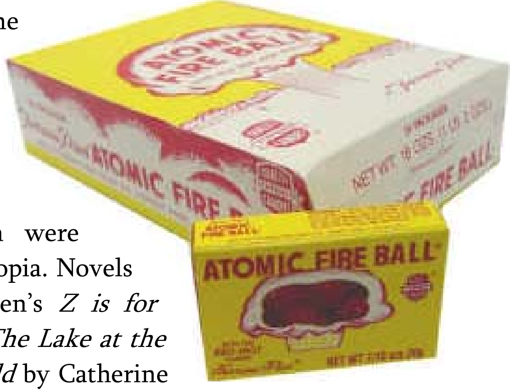
The age of atomic pop culture had begun. To the average American citizen the atomic bomb connoted power, ingenuity and supremacy.

This fascination with uranium and the bomb made its way into the cinemas. The 50s and 60s saw the release of movies including *Operation Uranium* in 1965 ("It was terror disguised as a woman!"), *The Gamma People* in 1956 ("Mad Dictator Rules Country With Deadly Gamma Ray!"), and also in 1956 the movie *The Atomic Man* ("THIS was the deadliest secret of all… the MAN with the RADIO-ACTIVE BRAIN!"). Uranium was as exciting as gold during the gold rush—and resulted in the wacky western-style movies *Uranium Boom* ("The inside story of the atom-age boom towns!") and *Dig That Uranium* ("Boy—how their Geiger counters click when they meet those babes from the Badlands!"). And then there's the simply peerless (and equally inexplicable) movie of 1953, *Canadian Mounties vs. Atomic Invaders.*

Atomic war toys and games appeared shortly after World War II, including a board game that let players bomb Hiroshima and Nagasaki. By the time of the PC the craze was still going strong. *B-1 Bomber* involved dropping warheads on Moscow, and *Nuclear War* treated the subject with black humour. The Atari game *Missile Command* also dealt with nuclear warfare and had widespread popularity. *Trinity* was made for Apple II series computers and involved the original 1945 atomic bomb test named Trinity, as well as the bombing of Hiroshima and a future nuclear holocaust.

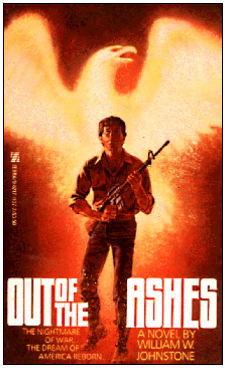
While kids were munching on 'Atomic Fire Ball' candy and teenage girls were wearing the radical new bikini (said by the designer to have 'an impact comparable to the bomb'—see feature on following page), teenage boys were reading comics

like *Atomic Mouse* and *Captain Atom.* The bomb was to have a wide influence on literature as a whole. While comics initially treated the subject lightly, the content became increasingly dark as the truth of atomic horrors settled over the public.

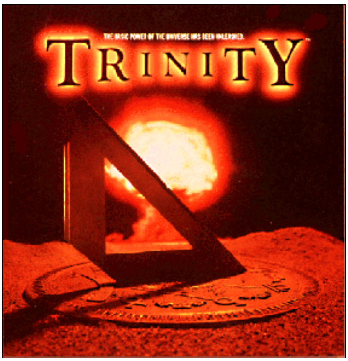


By the 1980s schoolchildren were saturated with stories of post-holocaust dystopia. Novels for young teenagers like Robert C. O'Brien's *Z is for Zachariah* and *The Lake at the End of the World* by Catherine McDonald instilled in us a deep-rooted fear of nuclear weapons, just as adults had been exposed to anti-nuclear themes in novels and movies including Kubrick's *Dr Strangelove*. However, not all nuclear stories had such noble themes.

"The Nightmare of War...The dream of America reborn". William W. Johnstone's *Ashes* novels were just a few in a glut of 80s atomic pulp novels whose heroes revel in the post-holocaust anarchy. Johnstone's stories see nuclear war as a cleansing apocalypse which will destroy all weak-kneed liberals, protesting college students and labour unions, and make possible the creation of a reactionary utopia.



Nowadays nuclear weapons tend to be portrayed in movies and on TV with more sophistication than in the 50s and 60s. The *Simpsons* spin-off comic *Radioactive Man* actually parodies the nuclear fixations of the 1960s. The current underlying most modern portrayals is, however, one of fear. Nuclear war or contamination is often treated as the ultimate evil which will occur if the hero does not succeed in his or her task. Whether it is the President making decisions in *Thirteen Days* (the dramatisation of the Cuban Missile Crisis), the characters in *Terminator 3* racing to avert a nuclear apocalypse, or Homer Simpson at the controls of a nuclear power plant, nuclear issues remain a part of our pop culture.



Some pics and facts from *Health Physics Historical Instrumentation Museum Collection* at http://www.orau.org/ptp/museumdirectory.htm and *Nuke Pop Homepage* at http://www.wsu.edu/~brians/nukepop/

the Bikini

On March 1, 1954, the United States government exploded a bomb called Bravo on the Bikini Atoll. With a force a thousand times greater than the one dropped on Hiroshima, it was the largest nuclear explosion ever, and just one of 23 tests done over Bikini.

Juda, the chief of the Bikini tribes, had said, “If the United States government and the scientists of the world want to use our island and atoll for furthering development, which with God’s blessing will result in kindness and benefit to all mankind, my people will be pleased to go elsewhere.” All 161 inhabitants were ‘temporarily’ relocated to Kili Island, 500 miles away.

In an act of carelessness, one of the bombs was detonated while the winds were blowing in the wrong direction. This showered radioactive pulverised coral and other material over a 50,000 square mile area including several inhabited islands and vessels.

Three out of four Bikini children under 10 later developed thyroid tumours. The island remains uninhabited to this day, with its entire population physically and culturally displaced. The United States paid them $20.6 million dollars for resettlement—less than one thousandth of the amount it spends each year preparing to fight a nuclear war—and gave $53 in compensation to a US serviceman who was caught in the fallout.

Four days after the Bravo explosion, the fashion industry sunk self-promotional cuteness to a new depth when French designer Louis Réard launched his new swimsuit, the bikini, so-named because he thought it would have “an impact comparable to the bomb”.

Scientists stress that any notion bikini wearing can lead to thyroid cancer and traumatic acculturation is wholly unsubstantiated.

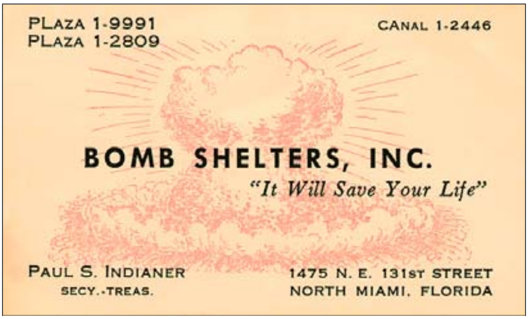
Paranoia

On 29 August 1949, the Soviet Union detonated its first atomic bomb, nicknamed ‘Joe One’. Already afraid of the threat communism posed to ‘the American way of life’, the United States’ love affair with nuclear energy soon ended.

In January 1951, Congress established the Federal Civil Defence Administration to develop community bomb shelters and educate the public about nuclear defence. What this involved was issuing school children with dog tags so that their bodies could be identified after a nuclear attack, and teaching them the technique of ‘atomic falling’ (collapsing into a foetal position with the head tucked under the hands), to be practised each night before going to bed.

Pamphlets and films were distributed by the Atomic Energy Commission about how to survive a nuclear attack: ‘What do you do when you see the flash? Why, duck and cover! That flash means, act fast!” If you followed the four survival secrets, ‘you have nothing to fear: (1) try to get shielded; (2) drop flat on the ground or floor; (3) bury your face in your arms; (4) never lose your head.’

Bomb shelter companies appeared and advertised shelters ranging from the economical foxhole ($13.50) to the expensive $3500 model with Geiger counter and phone. Life magazine even ran a story on a young newlywed couple who spent their honeymoon in a steel-and-concrete room 12 feet underground. “Fallout can be fun,” the article said.



Tranquilliser sales increased: 'By all means, provide some tranquillisers to ease the strain and monotony of life in a shelter. A bottle of 100 should be adequate for a family of four. Tranquillisers are not a narcotic and are not habit-forming.'

The Mosler Safe Company gained instant business after being awarded the contract to build two giant blast doors for a Congress fallout shelter. The doors were designed to protect vehicular entrances to the secret shelter located under the Greenbrier Resort in White Sulfur Springs in West Virginia. Employees of the company can be seen in the photo opposite posing by one of the doors, which was 49.5 centimetres thick and weighed more than 20 tonnes.

From the booklet *You And Atomic Warfare*, distributed by the U.S. Government in 1953:

YOU AND ATOMIC WARFARE

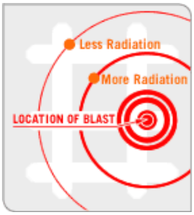
YOU'VE GOT TO LIVE WITH AN A-TOMIC BOMB! For the rest of your life, you have to expect that atomic or hydrogen bombs may be used against you on the battlefield, at home, in cities or on farms. At any time, you may come under an atomic attack. You have to learn to fight with it and to protect yourself against its effects in order to survive in this world of ours.

These bombs are terrible weapons, but they do not mean the end of all life as many people think. You can live through an atomic attack, and by taking common-sense precautions, live to fight another day. When any large bomb such as an A-bomb, goes off, there will be an area close to the bomb where, if you are unlucky enough to be there, you're dead beyond any question of a doubt! This area is relatively small, even with 1953 mode bombs and it is a matter of luck whether yo are at this spot or not. However, there is a muc larger area round this central "ground zero" ar where, if you do the wrong thing, you will be k ed; but, if you take the proper action, you hav good chance of surviving unhurt. This is the z where reflex action and proper training can tect you. This is the area where this article help save your life!

"Fallout can be Fun!" Newlyweds Maria and Mel Mininson in their fall-out shelter after winning a *Life* magazine competition.

The most infamous of all U.S. Civil Defence Films: "Duck and Cover!" —survive the holocaust by getting under your school desk.

What To Do In Case of Nuclear Attack



Locate the blast epicentre and run towards it.

Find the source of the radiation.

Remove any barriers between you and the source.

Expose yourself to the radiation for as long as possible.

You will soon become a comic book superhero with awesome powers.

Atomic Mouse

Atomic Mouse, of the eponymous comic, gets his super powers by ingesting radioactive U-235 pills provided by Professor Invento. Does he die of cancer? No! He is simply empowered to protect the citizens of Mouseville from the evil Count Gatto and his inept sidekick Shadow.

Bushido

The crime-fighting heroes in this 1988 comic gain their super powers through the exposure of their parents to the radiation of the Hiroshima bomb.

Captain Atom

Nathaniel Christopher Adam gets blasted by radiation in 1960 in a secret US government test. He becomes Captain Atom of Charlton/DC Comics, gains amazing powers and never looks back.

Teenage Mutant Ninja Turtles

Four turtles fall into the sewers of New York where a strange glowing green goop transforms them into the stuff of legend.

Spider Man

Peter Parker is attending a high-school demonstration of radiation technology when a spider creeps into the beam of radiation and bites his hand. Does he need chemotherapy or antivenom? Not when he’s got new superhuman spider-like abilities!

Roger Ramjet

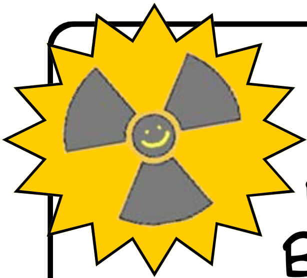
The All-American hero harnesses the basic mechanisms of nuclear chain reactions with his ‘proton energy pill—gives me the strength of 20 atom bombs for the period of 20 seconds!’

Daredevil

When Matt Murdoch saves a blind man from being hit by a truck, some of the radioactive waste inside the truck spills into Matt’s eyes and blinds him permanently. Luckily, the super power of radiation gives him superhuman hearing, smell and touch to compensate.

The Incredible Hulk

Bruce Banner was a nuclear physicist who developed a new gamma bomb for the US military. When a reckless teenager strayed onto the bomb test site, Dr Banner saved him but was caught in the middle himself. The radiation transformed him into a huge green monster, enormously strong and driven by fury.



GREAT USES FOR OLD NUCLEAR WEAPONS #4:

DIG A CANAL, BUILD A HARBOUR

Ed Teller was a bit crazy. He was the guy who promoted the Star Wars missile programme to Ronald Regan. This idea involved blasting nuclear missiles out of the air with, well, other nuclear missiles, or with x-ray lasers powered by thermonuclear explosions. Good work.

When peace became all the rage, he didn't think nuclear weapons should get ruled out altogether. He became involved in Project Plowshare, a US government project to find peaceful applications for nukes. In 1958 he tried to sell to Alaska a plan to create a new harbour on the northwest coast by exploding six nuclear bombs there. Luckily, protest from an Eskimo tribe that lived thirty miles away stopped the project—but not before the federal Atomic Energy Commission (AEC) had put in a formal request for 1,600 square miles of land for the explosion.

Plowshare also promoted the use of atomic bombs in mining and for altering the weather. The AEC also wanted to give private construction companies nuclear weapons for use in excavation.

The Plowshare project's biggest plan was to create a new Panama Canal by using nuclear explosions. The Russians, not wanting to be left behind, started projects of their own. Russian professor G. Poskrovsky was very excited about the whole thing: “One can straighten out the beds of large rivers to construct gigantic dams, cut canals literally in minutes... the cold current that washes our transpolar region can be made warmer than the Gulf Stream. The tundra will disappear, the subtropics will reach up to Moscow, and in Kolyama, there will be the climate of France”. And, as a bonus, you will be able to see the landscape even when it's dark.

The Panama project was only abandoned in 1970 and the Plowshare project continued to get funding until as recently as 1974. The Russian project wasn't abandoned until 1988 when the first ‘green’ movement started, following the Chernobyl disaster.

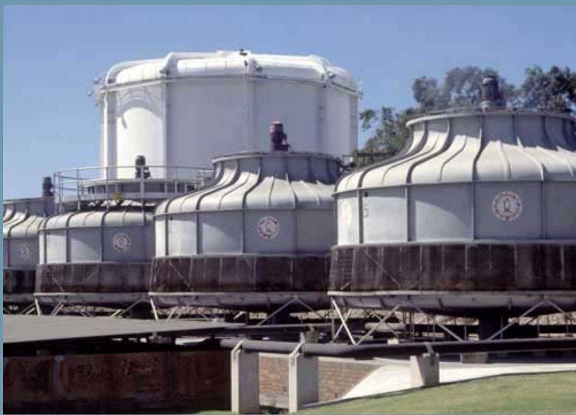
The above crater, named Sedan, was formed in one of the test blasts for project Plowshare.

A nuclear bomb equivalent to a hundred thousand tonnes of TNT was detonated 195 metres below the surface. The force of the blast displaced 11 million tonnes of rock and sand, leaving a crater 390 meters across and 100 metres deep. The road at the bottom right of the picture gives an idea of scale.

Edward Teller thought radioactive craters like this could be tremendously useful.

lucas heights nuclear reactor

a few facts. fallacies and conjectures



facts

The High Flux Australian Reactor (HIFAR) has operated at Lucas Heights, 30 kilometres south-west of Sydney, since 1958. It is the only operating nuclear facility in Australia.

Although it was originally built to test materials for planned nuclear power reactors in Australia, no nuclear power plants were pursued and the reactor's role changed. It is currently used for materials research, to produce radioactive isotopes for medicine and industry, and to irradiate silicon for the high performance computer industry. The biggest customers for HIFAR's radioisotopes are the nuclear medicine departments of hospitals and clinics in Australia and overseas.

How safe is it to live close to the reactor? Pretty safe. In the worst-case scenario of a radioactive plume being released from the reactor, the worst possible health effects to an individual as a result of this would involve a child who spent the first 12 hours after the accident on the trail bike track 400 metres north of the reactor. Assuming worst-case weather conditions, namely that the wind was blowing in that direction and that it was raining, and taking into account any subsequent contamination of surrounding land and food, the radiation dose that this individual would receive is 3.4 milliSieverts[†]. This is equivalent to being exposed to six medical x-rays, and is less than that requiring any emergency countermeasures. It is, however, 3.4 times the annual public exposure limit and therefore not trivial. Given the low risk of occurrence (one in a million per year), and the low likelihood of such worst-case conditions, it can however be considered a logically acceptable risk. [[†] Source: Draft Environmental Impact Statement, http://www.ansto.gov.au/ansto/RRR/eis_overview.html]

fallacies

It is often claimed that the Lucas Heights reactor is unnecessary, as medical radioisotopes can be made by cyclotrons (machines which use high voltages and electric fields to smash hydrogen atoms into a target, producing radioactivity). Although this is technically achievable, it is highly impractical, as outlined below.

- It is more difficult to make radioisotopes in a cyclotron than a reactor. Cyclotron reactions are less productive, less predictable, and unable to produce many of the isotopes available from a reactor.
- Technetium-99m, used in 80-85% of all medical applications, is indeed one of the few isotopes which can be produced in a cyclotron. However, whereas the raw materials for reactor production are cheap (a few dollars per kilogram), the materials needed for cyclotron isotope production—a rare form of highly-enriched molybdenum—cost millions of dollars per kilogram. These costs would put many medical treatments out of the reach of the public.
- The half-life of technetium is six hours. Therefore, if produced in a cyclotron, it would have to be made immediately before it is required, and must be able to be handled and transported to its location quickly. This would require a network of cyclotrons across Australia. In contrast, a reactor does not produce technetium directly, but rather molybdenum-99, which has a half-life of 66 hours and decays to form technetium. This can then be 'milked' from the molybdenum as required. Thus, the weekly production of molybdenum in a reactor is able to serve all of Australia's hospitals. This is one reason why none of the many cyclotrons around the world are used for the manufacture of technetium-99m.
- The technetium-99m produced in a cyclotron is also of lower purity than a reactor product. The presence of impurities, notably technetium-96, can expose patients to much higher radiation doses than necessary, and degrade the quality of the medical image.

Thus, although cyclotron production of isotopes is achievable, it is certainly not feasible.

conjectures

It is likely, given the technology used in the reactor and the political climate at the time of design, that Lucas Heights was built to produce weapons-grade nuclear material. This intention was, however, abandoned after construction.

It has been suggested that the unspoken reason for Lucas Heights' continuing operation is neither research nor medical isotope production (the isotopes, after all, can be imported from overseas), but rather to maintain Australia's right to a seat on the International Atomic Energy Agency. However, this theory is discredited by the fact that New Zealand, which has neither nuclear facilities nor natural uranium deposits, is not only a member state of the IAEA but also has a chair on the Board of Governors.

Sick to death of those half-arsed DIY projects that constantly assail you? Want something a bit more challenging and exciting than a picture frame or another bloody water feature? Then why not follow in the footsteps of one American teenager and...

Build Your Own Breeder Reactor!

Article by Daniel Carmody

That's right, be the envy of all your friends with your very own **nuclear breeder reactor** - it doesn't just generate energy, it also creates new fuel for the reactor core! And when you see the ease with which 17 year old David Hahn made his, you'll be kicking yourself that you don't have a dangerous ball of radioactive material to sit on your coffee table as an elegant talking point.

You Will Need:

Aluminium foil
Duct tape
A reasonable quantity of fissionable material

Here's How:

"The newspapers have published numerous diagrams, not very helpful to the average man, of protons and neutrons doing their stuff.... But curiously little has been said, at any rate in print, about the question that is of most urgent interest to all of us, namely, "How difficult are these things to manufacture?"

-George Orwell, "You and the Atom Bomb," 1945

David Hahn began his nuclear experiments in 1991, at the age of fifteen, some two years before he hit upon the idea a making a breeder reactor. Determined to irradiate anything he could, he decided to build a neutron 'gun'. Posing as a physics teacher, he wrote to a number of bodies such as the Nuclear Regulatory Committee (NRC) requesting information about obtaining and isolating the radioactive material. In these interesting times in which we live, I suggest that attempting this may not be the wisest course of action as it may result in a friendly visit from the good folk at ASIO. Happily, the information he obtained is still useful to the budding breeder reactor builder: americium-241 could be found in smoke detectors; radium-226, in antique luminous dial clocks; uranium-238 and minute quantities of uranium-235, in a black ore called pitchblende; and thorium-232, in gas lanterns. When he asked about the risks, the director of the NRC assured him the "real dangers are very slight," since "possession of any radioactive materials in quantities and forms sufficient to pose any hazard is subject to Nuclear Regulatory Commission (or equivalent) licensing." So that's okay then.

To obtain americium-241, he contacted smoke-detector companies and claimed that he needed a large number of the devices for a school project, extracted the americium components and

welded them together with a blowtorch. He placed this lump in a block of lead with a small hole pricked in one side to allow the alpha rays to stream out. In front of this, he placed a sheet of aluminium, which absorbs alpha rays and spits out neutrons in the process. He now had his neutron gun.

Ready to irradiate, he obtained some pitchblende in the hope isolating uranium from it. This proved unsuccessful, and so he turned his attention to thorium-232, which produces fissionable uranium-233 when bombarded with neutrons. He purchased thousands of lantern mantles and reduced them to a pile of ash with the blowtorch. To isolate the thorium from the ash he used lithium, obtained by cutting lithium batteries in half with wire cutters. He placed the lithium and the thorium dioxide together in a ball of al-foil and heated it with a bunsen burner, purifying the thorium to at least 9000 times the level found in nature, and up to 170 times the level that requires NRC licensing. However, his neutron gun was not strong enough to transmute thorium into uranium, so he began to prepare radium for an improved gun.

Here's one I prepared earlier

David obtained his radium by chipping the paint off antique luminous clocks, until one day when he discovered a whole vial of the radium paint left inside a clock. To concentrate the radium, he secured some barium sulphate from the X-ray ward at a local hospital and heated it until it liquefied. He dissolved the paint chips in this solution, then dried it into crystalline salts, suitable for packing into the lead block. Having learned from the NRC that "nothing produces neutrons from alpha reactions as well as beryllium", he got a friend to nick a strip of beryllium from a chemistry lab and placed in front of the lead block. Armed with his new radium gun, he began to irradiate his thorium and pitchblende, measuring the results with his Geiger counter. While his thorium seemed to become more radioactive, the pitchblende remained a disappointment. Writing once more to the NRC, he discovered that the neutrons were too 'fast', and he would have to slow them down using some kind of filter. Ordinary water suffices, but if you are fond of a challenge you can do what he did and collect tiny amounts of tritium from glow-in-the-dark gun sights and smear it over the beryllium. Either way, the neutrons were now slow enough to interact with the uranium, and the pitchblende began to become more radioactive.

Now 17, he hit upon the idea of

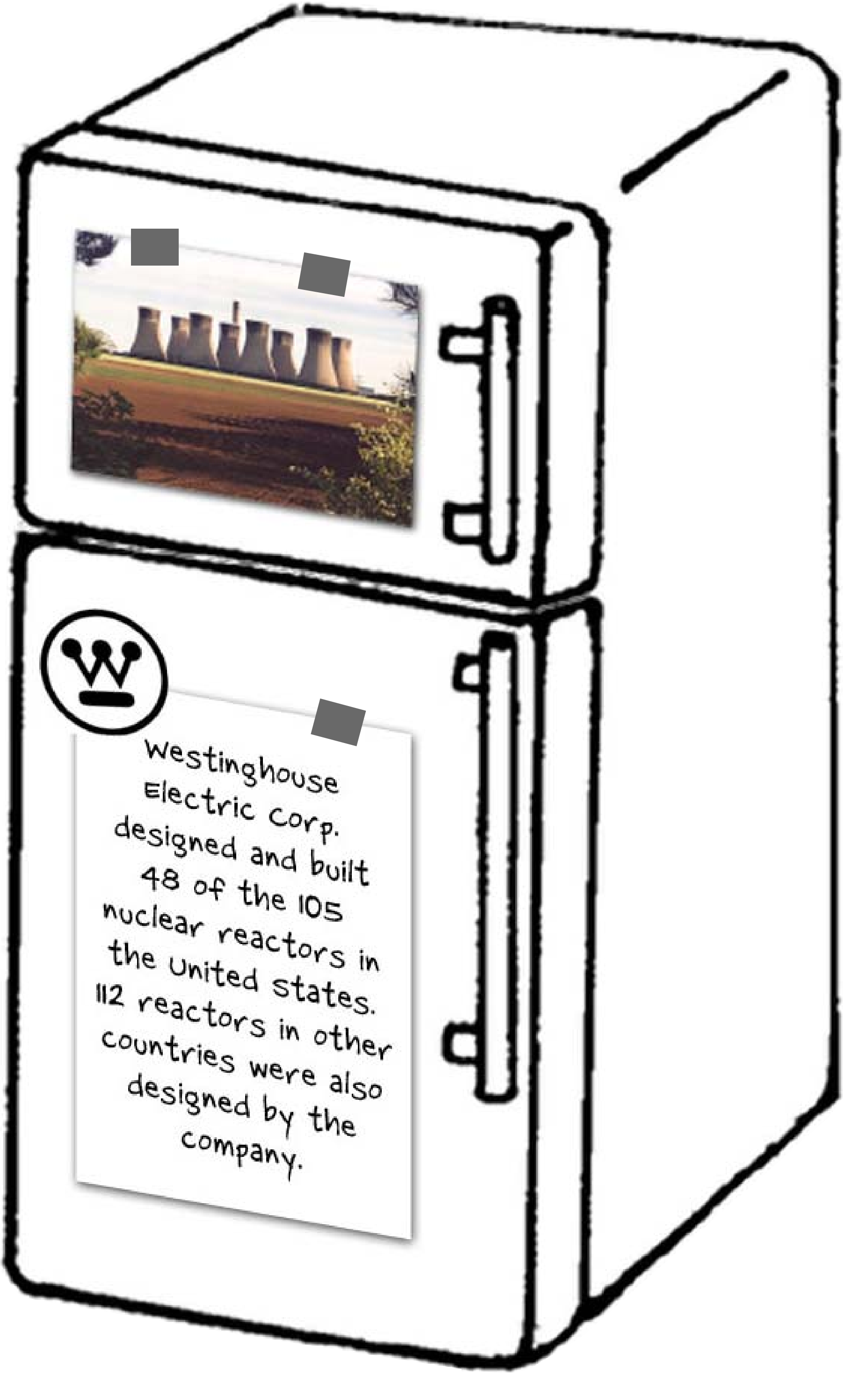
making a model breeder reactor (he knew he had insufficient material to sustain a chain reaction, but was determined to get as far as he could by trying to get his various radioisotopes to interact with one another). The neutron sources from his guns became the reactor core - the radium and americium wrapped up with beryllium and aluminium shavings in a radioactive ball of alfoil. Around this he placed a blanket composed of tiny foil-wrapped cubes of thorium ash and uranium powder, which were stacked in an alternating pattern with carbon cubes and tenuously held together with duct tape. David monitored his breeder reactor with his Geiger counter. "It was radioactive as heck," he says. “The level of radiation after a few weeks was far greater than it was at the time of assembly.” Beginning to become concerned about the safety of his project, he purchased a set of cobalt drill bits and inserted them into his reactor to serve as control rods. When his Geiger counter began picking up radiation five doors from his mum's house, he decided that he had "too much radioactive stuff in one place" and began to disassemble the reactor. He hid some of the material in his mother's house, left some in the shed, and packed most of the rest into the boot of his car.

At 2:40 am. on August 31, 1994, Clinton Township police responded to a call concerning a young man who had been apparently stealing tires from a car. Upon searching his car, they discovered a toolbox shut with a padlock and sealed with duct tape. The trunk also contained foil-wrapped cubes of mysterious grey powder, small disks and cylindrical metal objects, and mercury switches. The police were especially alarmed by the toolbox, which David said was radioactive and which they feared was an atomic bomb. The discovery eventually triggered the Federal Radiological Emergency Response Plan, and when the EPA investigated the shed in which David had performed his experiments they found debris contaminated at up to 1000 times the normal levels of background radiation. After the moon-suited workers dismantled the shed, they loaded the remains into sealed barrels that were trucked to the Great Salt Lake Desert. There, the remains of David's experiments were buried with other radioactive debris.

The moral to this story: don’t get panicky and try to dump the evidence when your reactor gets all radioactive. It’s supposed to do that. Happy reactor building, folks.

Disclaimer: The author would like to point out that he does not condone the actual construction of a model nuclear breeder reactor. For obvious reasons. He would also like to make it clear that he is in no way responsible for any misfortune that may befall someone who does try it, and that anyone who is that bloody stupid deserves everything they get.

Quotes and information obtained from 'Tale of the Radioactive Boy Scout' by Ken Silverstein, Harper's Magazine, Nov 1998.


Westinghouse Electric Corp. designed and built 48 of the 105 nuclear reactors in the United States. 112 reactors in other countries were also designed by the company.

We Love You, Radioactive Waste

“One of the most deeply ingrained anti-nuclear myths is that there is no safe way to get rid of nuclear waste.” [1]

Methods of high level waste disposal include vitrification (sealing in glass; used in Great Britain and France), copper encapsulation (developed in Sweden), and Synroc (a synthetic ceramic invented in Australia).

“The challenge of radioactive waste disposal is not so much that presented by the wastes themselves as it is to define the level of safety that will be acceptable. Objectors demand nothing less than absolute safety, which is an unattainable goal in any endeavour.” [2]

“Nuclear power does not add any radioactivity to the Earth; on the contrary, it reduces the radioactivity that Mother Nature would otherwise be producing.” [3]

“For the same power, nuclear wastes are some 3.5 million times smaller in volume [than wastes from fossil-fired power plants].” [4]

[1] Colin Keay, *Nuclear Common Sense*, 2003
[2] ibid.
[3] P. Beckman, *The Non-Problem of Nuclear Wastes*, 1979
[4] ibid.

Radioactive Waste Sucks

“What can be done with radioactive waste? This extremely difficult question has not really been answered anywhere in the world.” [1]

To clean up the existing radioactive waste in the United States alone will cost about 400 billion dollars and take 75 years. [2]

The standards to which nuclear waste disposal methods are tested in the U.S. are based on obsolete regulations established in 1965, many of which are inadequate. [3]

Many towns around the world have become severely polluted by nuclear waste. In 1964, drinking one glass of water per day from the Columbia River, 30 km downstream from the Hanford Nuclear Reservation in fertile south-east Washington State, U.S., resulted in a 4 millirem dose of radioactivity [4]. [For an idea of health effects, compare to Radithor on p11.]

“Many of the problems [in the U.S.] are equally or even more pressing in other countries, especially Russia.” [5]

[1] *Physics Today*, American Institute of Physics, June 1997, p 22
[2] *National Geographic,* July 2002, p 9
[3] *National Geographic,* July 2002, p 31
[4] Peter Goin, *Nuclear Landscapes,* 1991
[5] *Physics Today,* American Institute of Physics, June 1997, p 32

fusion

When people talk about nuclear fusion, they often do so with a starry-eyed expression normally reserved for thoughts of world peace and an end to hunger. As an energy source that's cheap, inexhaustible and safe, nuclear fusion could indeed be just what the doctor ordered for the 21st century. Here we give you the beginners' guide to fusion.

Nuclear fusion is the process of converting hydrogen to helium that fuels our sun and other stars. In contrast to nuclear fission, which splits large atoms of uranium to release energy, nuclear fusion slams smaller atoms together. The basic fuel for fusion machines is ordinary sea water—a cheap and almost limitless resource—from which deuterium (an isotope of hydrogen) is extracted. Tritium, the other reactant, is a rarer isotope of hydrogen and is manufactured from lithium within the machine. Lithium is a metal abundant in the earth's crust and in seawater.

In order to slam these hydrogen nuclei together, they have to be heated up to high temperatures to overcome their natural electrostatic repulsion. Unfortunately, the temperatures required are around 100 million degrees—the temperature at the centre of a star. How to contain reactions at such high temperatures is a major obstacle.

One method is called magnetic confinement, and is used in a type of reactor called the Tokamak. The superhot hydrogen gas is contained inside a donut-shaped tube by the use of strong magnetic fields, which prevent the gas from touching (and hence vaporising) the tube walls. Before its decommissioning in 1997, the Princeton Tokamak was able to generate a record 10.7 million watts of power in a brief burst of energy lasting a fraction of a second. (By contrast, a typical nuclear fission plant generates a steady 1000 million watts of power.)

Another method, called inertial confinement, focuses laser beams on a small pellet of lithium deuteride to achieve fusion. The laser beams vaporise the surface of the pellet, causing a shock wave which implodes the pellet and generates the enormous temperatures and pressures required for fusion.

Neither design has yet reached 'break-even' point, meaning that both reactors consume more energy than they produce.

The fusion of deuterium and tritium produces helium and a neutron. The high-energy neutrons fly out from the reactor and are absorbed by water-carrying tubes which surround the core. The neutrons heat the water, which boils, turns to steam and drives a turbine to generate power, as in a hydroelectric or coal-fired power plant.

Currently, no fusion reactor is able to keep the hot reaction gasses stable for a long enough time to be useful. The hope is, however, that with continuing progress, fusion might become a viable, safe, clean and cheap energy source. The next big step is the International Thermonuclear Experimental Reactor (ITER), a joint effort of several countries, which aims to sustain fusion for many minutes.

A rough timeline for when we might expect progress in fusion is:

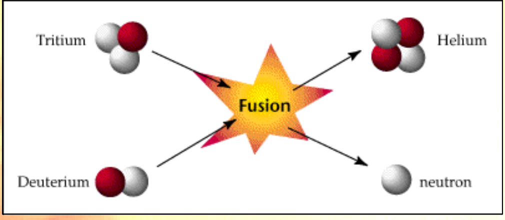
- by 2014: creation of a 1000-megawatt ITER fusion plant
- by 2025: demonstration of a fusion power plant
- by 2035: the first commercial fusion power plant
- by 2050: widespread use of commercial fusion power plants.

A fusion reactor would have several strong advantages over current fission reactors. Firstly, a fusion reactor will not create tonnes of high-level nuclear waste per year, as uranium reactors do. The only wastes from a fusion reactor would be the steel hull, which gradually becomes radioactive; helium atoms, which are a significant component of the atmosphere already; and any tritium that might escape. Tritium is a radioactive isotope of hydrogen with a half-life of 12.5 years. Tritium is less dangerous than the by-products of fission reactors because it has a shorter lifetime, is unlikely to cause damage unless it is directly inhaled, and if it is taken into the body it will likely be in the form of water, which the body does not retain for long periods of time.

Secondly, fusion plants are not subject to meltdowns. A meltdown occurs when the heat of the reaction core melts through its containing vessel and releases radiation into the environment, as almost occurred at Three Mile Island. If containment were lost in a fusion reactor, all nuclear reactions would immediately cease due to the loss of temperature and pressure required to sustain reaction.

Thirdly, a fusion reactor cannot go supercritical, as occurred in the ‘run away’ reaction at Chernobyl.

One possible disadvantage is shared by both fusion and fission reactors. The neutron radiation from both is strong enough to cause a weakening of the metal containment structure, possibly causing a ‘brittle fracture’. Until a working demonstration fusion reactor is built, it is hard to say whether other problems will present themselves.



Information from Michio Kaku, *Visions*, 1997 and ITER homepage at www.iter.org

www.nerdling.net

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